# MECHANISMS in Modern Engineering Design

*A Handbook*
*for Engineers,*
*Designers and Inventors*

by IVAN I. ARTOBOLEVSKY, D. Sc. (Eng.)
Member, USSR Academy of Sciences

*Volume*

**II**

## Lever Mechanisms

*Part 1*

*Translated*
*from the Russian*
*by Nicholas Weinstein*

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# PREFACE

The second volume of *Mechanisms in Modern Engineering Design,* like the first volume, is devoted to lever mechanisms. In the two parts of Vol. II the reader will find the drawings and descriptions of various kinds of lever mechanisms made up of turning and sliding pairs. This volume also contains combined mechanisms: lever-cam, gear-lever, lever-ratchet, etc. Lever mechanisms with flexible and elastic links are collected in separate sections. Part 2 of Vol. II closes with the drawings and descriptions of wedge-lever and lever-screw mechanisms. All in all, the second volume contains 1376 mechanisms.

A total of 2288 lever mechanisms are included in Vol. I and in the two parts of the present volume. Classifications of these mechanisms, based on their structural features and on their functions, are to be found in the introduction to Vol. I. All the necessary instructions for using the schematical representations, descriptions and the adopted systems of classification can also be found there. Subject indexes at the back of each part of Vol. II list the mechanisms in alphabetical order.

The author is genuinely grateful to the late V.A. Zinovyev for his valuable assistance in the publication of this volume.

Please send all comments on shortcomings of this handbook, reports on errors found by readers and suggestions for future changes and supplementary data to I.I. Artobolevsky, Institute of Mechanical Engineering, Ul. Griboyedova 4, Moscow 101830, USSR. They will be appreciated.

# SECTION FOUR

# Link-Gear Mechanisms

# LG

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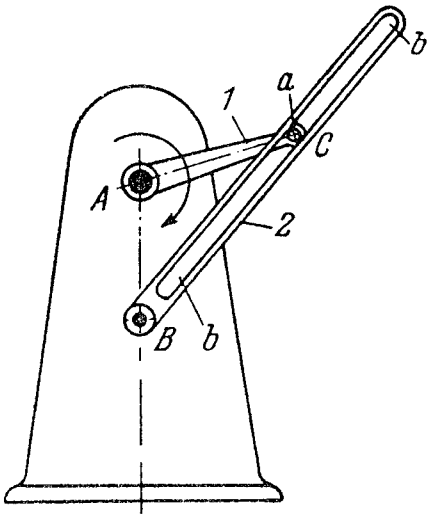
1. General-Purpose Three-Link Mechanisms 3L (913 through 927)
2. General-Purpose Four-Link Mechanisms 4L (928 through 993)
3. General-Purpose Five-Link Mechanisms 5L (994 through 999)
4. General-Purpose Six-Link Mechanisms 6L (1000 through 1027)
5. General-Purpose Multiple-Link Mechanisms ML (1028 through 1042)
6. Mechanisms for Generating Curves Ge (1043 through 1255)
7. Mechanisms for Mathematical Operations MO (1256 through 1318)
8. Brake Mechanisms Br (1319, 1320 and 1321)
9. Wobble Plate Mechanisms WP (1322 and 1323)
10. Hammer, Press and Die Mechanisms HP (1324 and 1325)
11. Governor Mechanisms G (1326 through 1329)
12. Valve Gear Mechanisms VG (1330 through 1336)
13. Dwell Mechanisms D (1337 through 1354)
14. Guiding Mechanisms and Inversors GI (1355 through 1376)
15. Switching, Engaging and Disengaging Mechanisms SE (1377)
16. Sorting and Feeding Mechanisms SF (1378 through 1381)
17. Operating Claw Mechanisms of Motion Picture Cameras OC (1382 through 1395)
18. Clutch and Coupling Mechanisms C (1396 and 1397)
19. Key Mechanisms K (1398)

20. Piston Machine Mechanisms PM (1399 through 1413)
21. Aircraft Landing Gear Mechanisms AL (1414 through 1443)
22. Mechanisms of Measuring and Testing Devices M (1444 and 1445)
23. Pantograph Mechanisms P (1446 and 1447)
24. Mechanisms of Other Functional Devices FD (1448 through 1474)

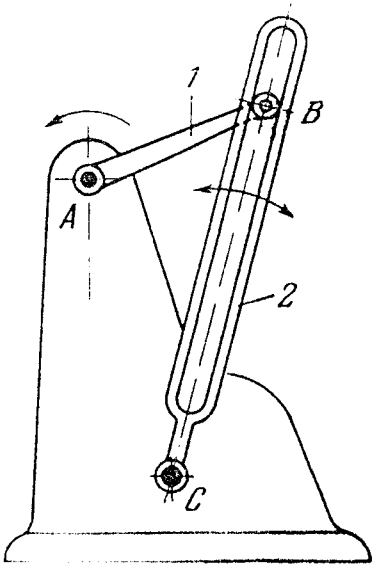
# 1. GENERAL-PURPOSE THREE-LINK MECHANISMS (913 through 927)

| 913 | THREE-BAR ROTATING-SLOTTED-LINK MECHANISM | LG 3L |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AC} > \overline{AB}$. Link *1*, rotating about fixed axis *A*, has pin *a* which slides along slot *b* of slotted link *2*. Slotted link *2* makes complete revolutions about axis *B*.

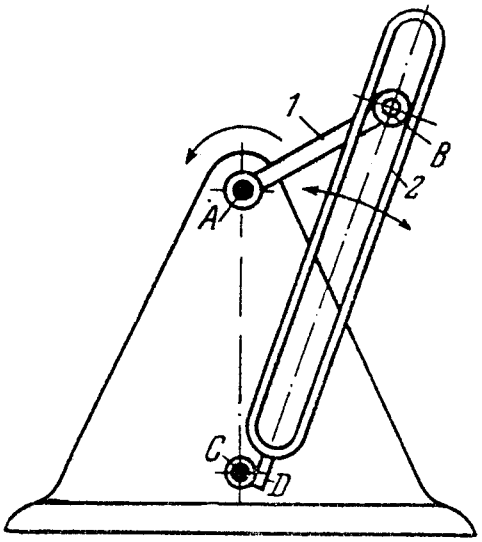
| 914 | THREE-BAR OSCILLATING-SLOTTED-LINK MECHANISM | LG 3L |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AB} < \overline{AC}$. Therefore, when link *1* makes one complete revolution about fixed axis *A*, slotted link *2* does not make a complete revolution but oscillates about fixed axis *C* through angle $\beta$, determined by the equation

$$\beta = 2 \arcsin \frac{\overline{AB}}{\overline{AC}}.$$

| 915 | THREE-BAR OFFSET-SLOTTED-LINK MECHANISM | LG 3L |
|---|---|---|

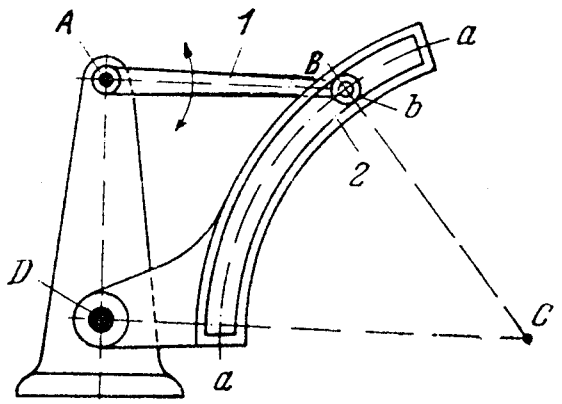



When link *1* rotates about fixed axis *A*, slotted link *2* oscillates about fixed axis *C*. The axis of slotted link *2* does not pass through centre *C* of slotted-link oscillation. The angle β of oscillation is determined by the equation

$$\beta = \arcsin\frac{\overline{AB}-\overline{CD}}{\overline{AC}} + \arcsin\frac{\overline{AB}+\overline{CD}}{\overline{AC}}$$

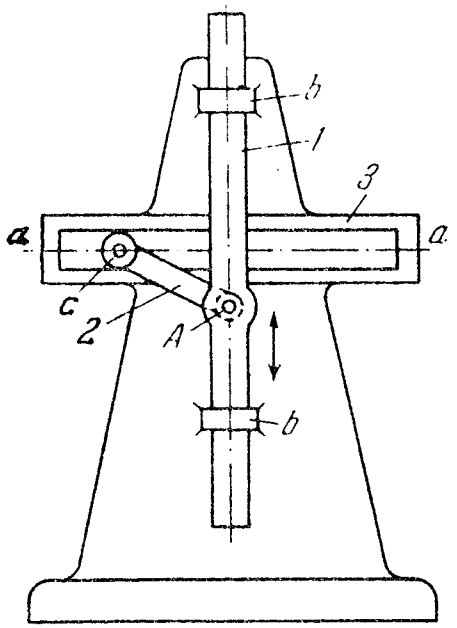
where $\overline{CD}$ is the distance between the axis of slotted link *2* and axis *C*.

| 916 | THREE-BAR CIRCULAR-SLOTTED-LINK MECHANISM | LG 3L |
|---|---|---|



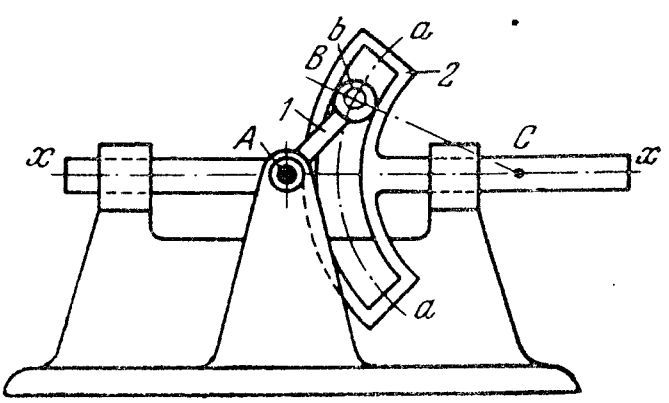

The lengths of the links comply with the conditions: $\overline{AB} + \overline{BC} < \overline{AD} + \overline{DC}$ and $\overline{AB} < \overline{AD} < \overline{BC} < \overline{DC}$. At the end of link *1* is pin *b* which slides in movable circular guiding slot *a-a* of radius $\overline{CB}$ and with its centre at point *C*. When link *1* oscillates about fixed axis *A*, slotted link *2* also oscillates (about fixed axis *D*). The mechanism is equivalent to four-bar double-swing linkage *ABCD* in which link *BC* is the connecting rod and links *AB* and *DC* are rocker arms.

| 917 | THREE-BAR SLOTTED-LINK MECHANISM WITH TWO GUIDING ELEMENTS (MODIFIED SCOTCH YOKE) | LG 3L |
|---|---|---|



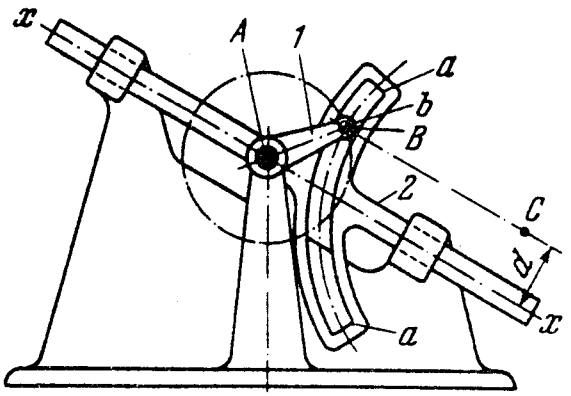

Link *1*, reciprocating in fixed guides *b-b*, is connected by turning pair *A* to link *2*. Pin *c* slides in fixed guiding slot *a-a* of link 3. The axes of guides *b-b* and guiding slot *a-a* are perpendicular to each other.

| 918 | THREE-BAR CIRCULAR-SLOTTED-LINK MECHANISM (MODIFIED SCOTCH YOKE) | LG 3L |
|---|---|---|



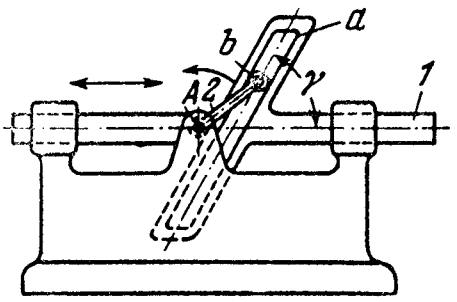

Link *1*, rotating about fixed axis *A*, has pin *b* which slides in movable circular guiding slot *a-a* of radius $\overline{BC}$ and with its centre at point *C*. When link *1* rotates, slotted link *2* reciprocates along axis *x-x*. The mechanism is equivalent to slider-crank linkage *ABC* in which *AB* is the crank, *BC* is the connecting rod and slotted link *2* is the slider.

| 919 | THREE-BAR CIRCULAR-SLOTTED-LINK MECHANISM (MODIFIED SCOTCH YOKE) | LG 3L |
|---|---|---|



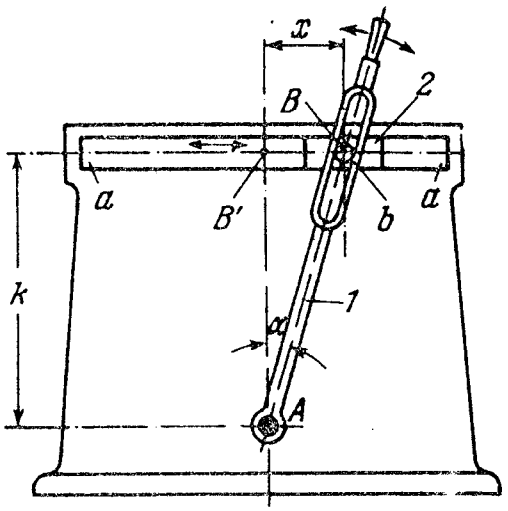

Link *1*, rotating about fixed axis *A*, has pin *b* which slides in movable circular guiding slot *a-a* of radius $\overline{BC}$ and with its centre at point *C*. When link *1* rotates, link *2* reciprocates along axis *x-x*. The mechanism is equivalent to offset slider-crank linkage *ABC* in which *AB* is the crank, *BC* is the connecting rod, slotted link *2* is the slider and *d* is the offset.

| 920 | THREE-BAR RECIPROCATING-SLOTTED-LINK MECHANISM (MODIFIED SCOTCH YOKE) | LG 3L |
|---|---|---|




Link *1* has slot *a* along which pin *b* of link *2* slides. The axis of the slotted link makes angle $\gamma$ with the direction of motion of link *1*. Angle $\gamma$ should be selected within the limits for which jamming of the mechanism is excluded.

| 921 | THREE-BAR SLOTTED-LINK TANGENT GENERATOR | LG 3L |
|---|---|---|



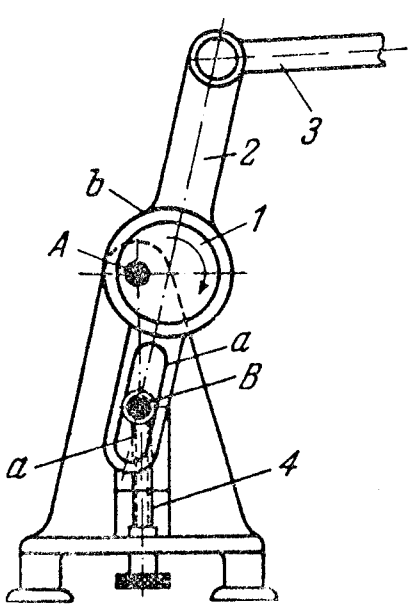

Slotted link *1* oscillates about fixed axis *A*. The slot of link *1* receives cylindrical pin *b* of slider *2* which reciprocates in straight guiding slot *a-a* of the base. The displacement of point *B* of slider *2* with respect to its middle position *B'* equals

$$x = k \tan \alpha$$

where $\alpha$ = angle of rotation of link *1*

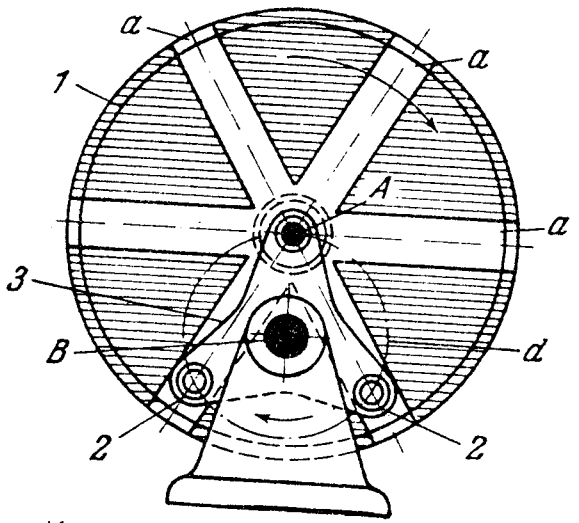
$k$ = distance from point *B'* to axis *A*.

| 922 | THREE-BAR LINK-GEAR MECHANISM WITH DRIVEN LINK STROKE ADJUSTMENT | LG 3L |
|---|---|---|




Link *2* has collar *b* encircling eccentric *1* which rotates about fixed axis *A*. Link *2* transmits motion to link *3* which is connected to a special device not shown in the drawing. Eccentric *1* oscillates link *2* whose slot *a-a* slides along stationary roller *B*. The stroke of link *3* can be changed with screw *4* by adjusting the distance between axis *A* and the centre of roller *B*.

| 923 | THREE-BAR SLOTTED-LINK MECHANISM | LG 3L |
|---|---|---|



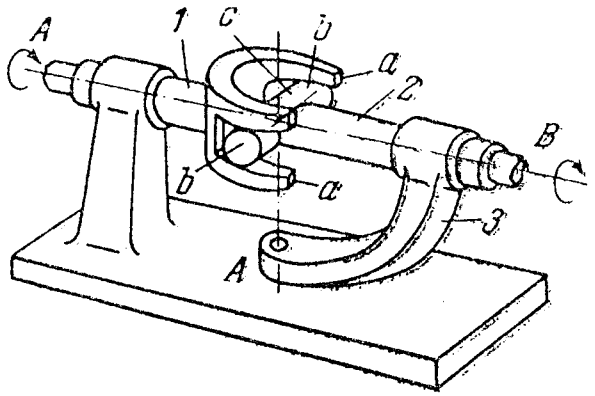

Slotted link *1* has the form of a disk with three equally spaced diametral slots *a* and rotates about fixed axis *A*. Link *3*, rotating about fixed axis *B*, carries three rollers *2* located on diameter $d = 2\,\overline{AB}$ at angles of 120° to one another. The provision of three slots *a* ensures equal force distribution and smooth motion of the mechanism. When link *3* rotates clockwise, rollers *2* slide along the diametral slots of link *1*, rotating it in the same direction. The transmission ratio between links *3* and *1* equals

$$i_{31} = \frac{\omega_3}{\omega_1} = 2.$$

Thus the angle of rotation of link *3* is always twice that of link *1*.

## 924 THREE-BAR SLOTTED-LINK SPHERICAL MECHANISM

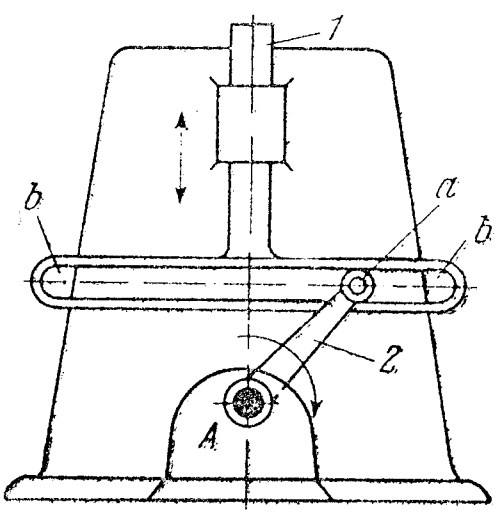
LG 3L




Slotted link *1* has two circular guiding slots *a*. At its left end, link *2* has two round cylindrical pins *b* which slide in slots *a*. The diameter of pins *b* equals the width of slots *a*. When bracket *3* is put into various positions by turning it about fixed axis *A* and clamping it, rotation can be transmitted from link *1* to link *2* under the condition that the axes of all the turning pairs, circular slot *a* and pins *b* intersect at a single point. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

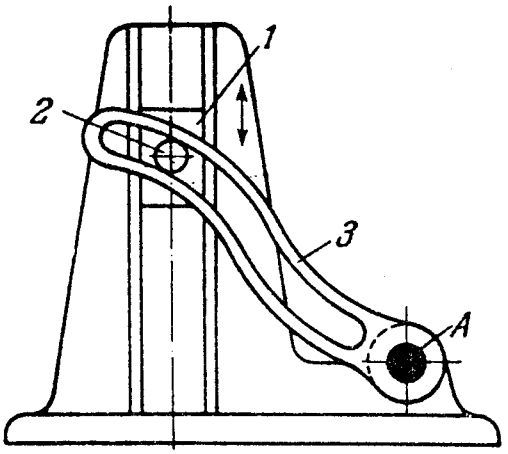
## 925 THREE-BAR STRAIGHT-SLOTTED-LINK MECHANISM (SCOTCH YOKE)

LG 3L



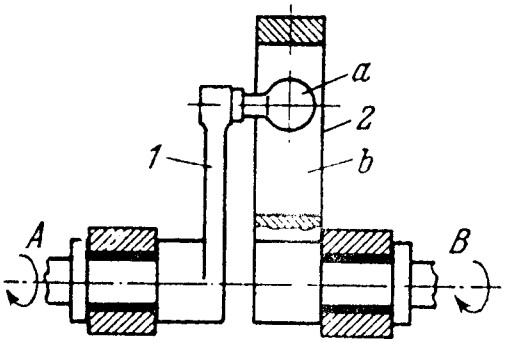

Link *1* reciprocates in a fixed guide. Link *2*, rotating about fixed axis *A*, has pin *a* which slides along slot *b-b* whose width equals the outside diameter of pin *a*.

| 926 | THREE-BAR CURVILINEAR-SLOTTED-LINK MECHANISM | LG, 3L |
|---|---|---|




Upon reciprocation of slider *1*, its cylindrical pin *2* slides along the curvilinear slot of slotted link *3* which oscillates about fixed axis *A*.

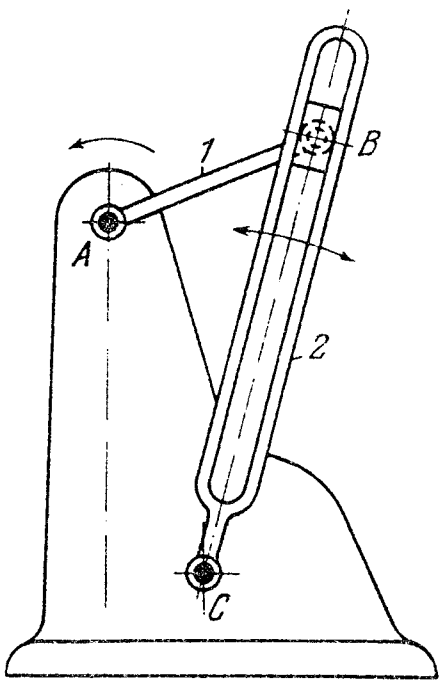
| 927 | THREE-BAR SPATIAL LINK-GEAR MECHANISM | LG 3L |
|---|---|---|




**Link *1*,** rotating about fixed axis *A*, has sphere *a* which is in contact with surface *b* of link *2*. Link *2* rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

## 2. GENERAL-PURPOSE FOUR-LINK MECHANISMS (928 through 993)

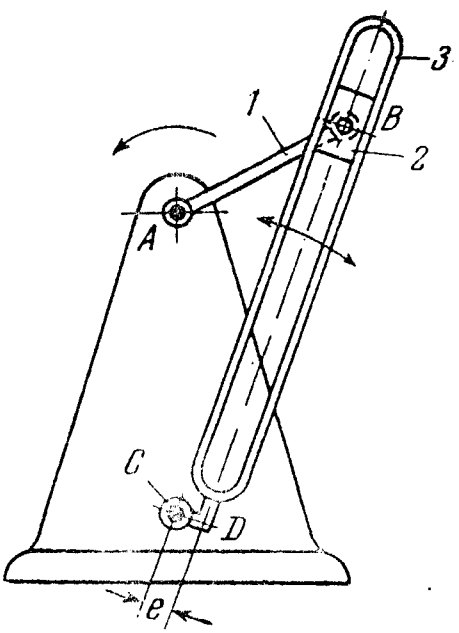
| 928 | FOUR-BAR OSCILLATING-SLOTTED-LINK MECHANISM | LG 4L |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AB} < \overline{AC}$. Therefore, when link *1* makes one complete revolution about fixed axis *A*, slotted link *2* does not make a complete revolution but oscillates about fixed axis *C* through angle β, determined by the equation

$$\beta = 2 \arcsin \frac{\overline{AB}}{\overline{AC}}$$

| 929 | FOUR-BAR OFFSET SLOTTED-LINK MECHANISM | LG 4L |
|---|---|---|

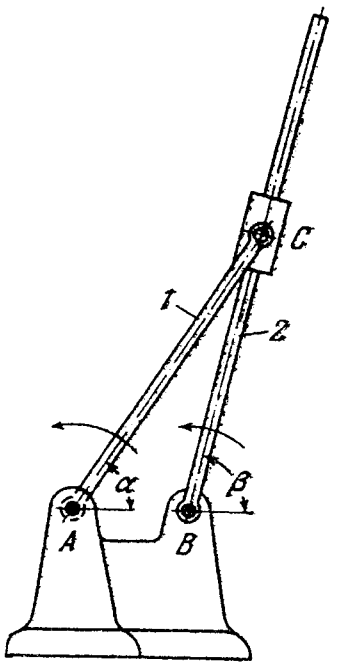



When link *1* rotates about fixed axis *A*, slotted link *3* oscillates about fixed axis *C*. The axis of slider *2* does not pass through centre *C* of slotted link oscillation. The angle β of oscillation is determined by the equation

$$\beta = \arcsin \frac{\overline{AB}-\overline{CD}}{\overline{AC}} + \arcsin \frac{\overline{AB}+\overline{CD}}{\overline{AC}}$$

where $\overline{CD} = e$ is the distance between the axis of slotted link *3* and axis *C*.

| 930 | FOUR-BAR ROTATING-SLOTTED-LINK MECHANISM | LG 4L |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AC} > \overline{AB}$. The angles $\alpha$ and $\beta$ of rotation of link *1* and link *2* about fixed axes *A* and *B* are related by the equation

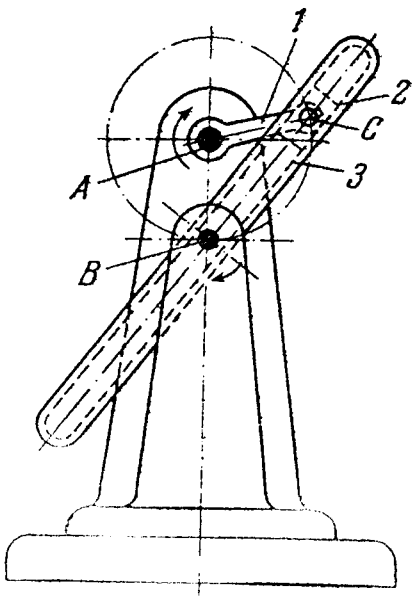
$$\tan\beta = \frac{\overline{AC}\sin\alpha}{\overline{AC}\cos\alpha - \overline{AB}}$$

The transmission ratio between links *1* and *2* equals

$$i_{12} = \frac{\sin\alpha}{\sin\beta}\,\frac{1}{\cos(\beta-\alpha)}\,.$$

Links *1* and *2* make complete revolutions about axes *A* and *B*.

| 931 | FOUR-BAR ROTATING-SLOTTED-LINK MECHANISM | LG 4L |
|---|---|---|

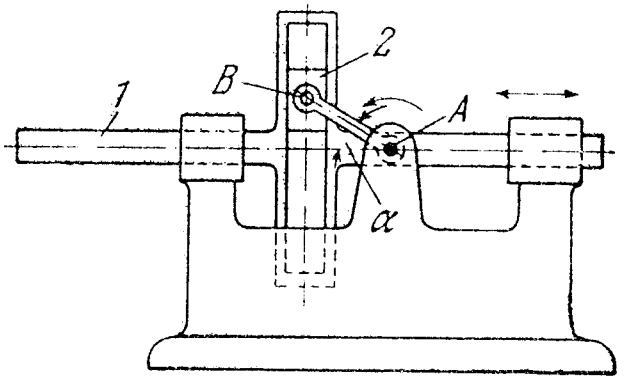



The lengths of the links comply with the condition: $\overline{AC} = \overline{AB}$. Crank *1*, rotating about fixed axis *A*, is connected by turning pair *C* with slider *2* which moves along the slot of link *3*. Link 3 rotates about fixed axis *B*. Crank *1* rotates slotted link *3* about axis *B*. The transmission ratio between links *1* and *3* equals

$$i_{13} = \frac{\omega_1}{\omega_3} = 2$$

where $\omega_1$ and $\omega_3$ are the angular velocities of links *1* and *3*. Thus slotted link *3* makes one revolution to two revolutions of crank *1*.

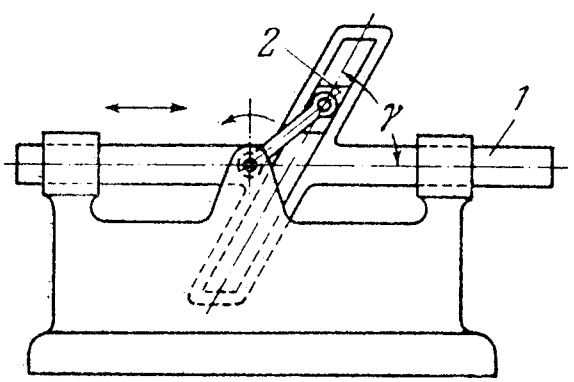
| 932 | FOUR-BAR RECIPROCATING-SLOTTED-LINK MECHANISM (SCOTCH YOKE) | LG 4L |
|---|---|---|




Link *1* has a slot along which slider *2* moves. The axis of the slot is perpendicular to the axis of motion of link *1*. The displacement of link *1* from its extreme left-hand position equals

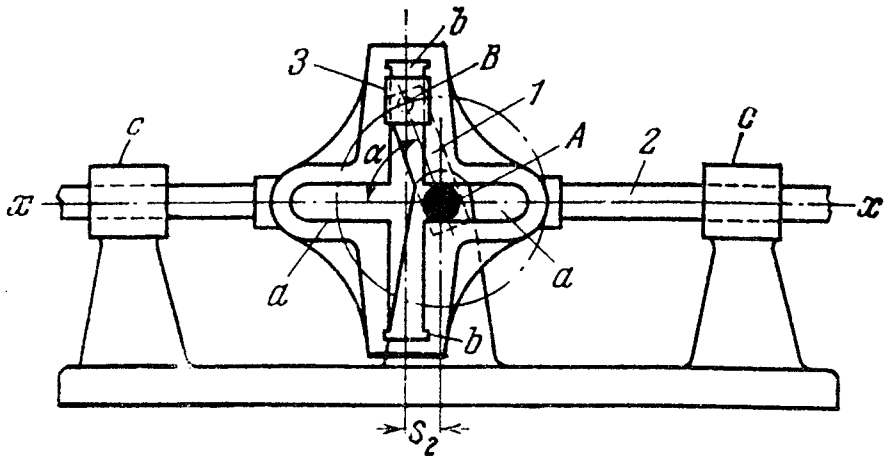
$$s = \overline{AB}\,(1 - \cos\alpha).$$

| 933 | FOUR-BAR RECIPROCATING-SLOTTED-LINK MECHANISM (MODIFIED SCOTCH YOKE) | LG 4L |
|---|---|---|



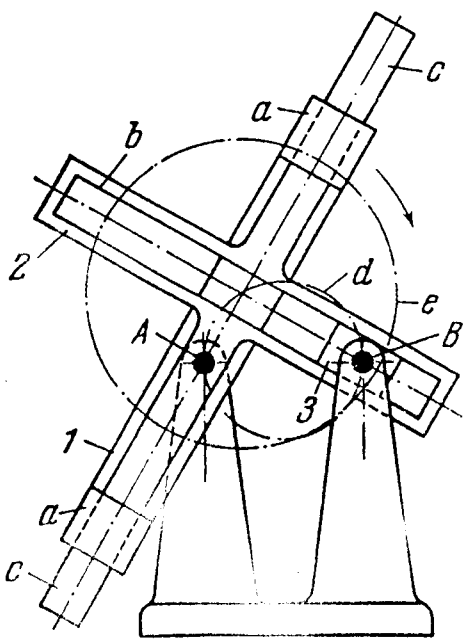

Link *1* has a slot along which slider *2* moves. The axis of the slot makes angle $\gamma$ with the direction of motion of link *1*. Angle $\gamma$ should be selected within the limits for which jamming of the mechanism is excluded.

| 934 | FOUR-BAR CROSS-SHAPED-SLOTTED-LINK MECHANISM (MODIFIED SCOTCH YOKE) | LG 4L |
|---|---|---|




Link *1* rotates about fixed axis *A*. Slider *3* moves in straight guiding slot *b-b* of link *2* which reciprocates in fixed guides *c-c*. Slot *a-a* slides along axle *A*. The displacement of link *2* is equal to $s_2 = \overline{AB} \cos \alpha$, where $\overline{AB}$ is the length of crank *1* and $\alpha$ is the angle made by *AB* with axis *x-x*.

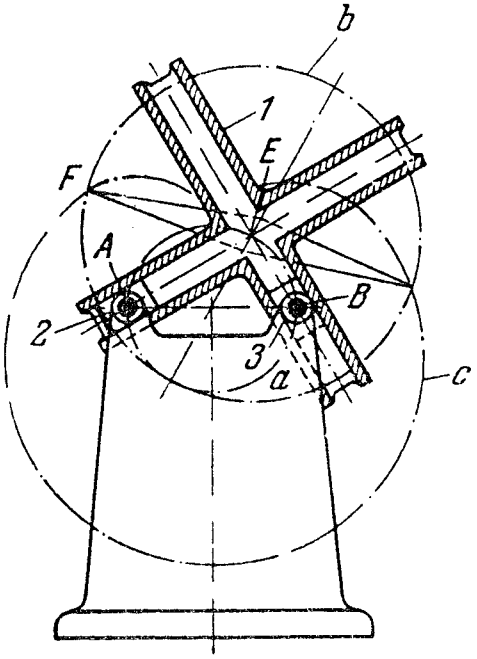
| 935 | FOUR-BAR DOUBLE-SLOTTED-LINK MECHANISM (MODIFIED SCOTCH YOKE) | LG 4L |
|---|---|---|




Link *1* with guides *a-a* rotates about fixed axis *A*. Link *2* is designed as slotted link *b* having two extensions *c* which slide in guides *a*. The angle between the axis of slotted link *b* and guides *a-a* equals 90°. Slider *3* rotates about fixed axis *B*. The mechanism has the constant transmission ratio $i_{13} = 1$. The motion of slotted link *2* is identical to the rolling of movable circle *e* without slipping around fixed circle *d*.

## 936 FOUR-BAR TWO-SLIDER SLOTTED-LINK MECHANISM (MODIFIED SCOTCH YOKE)

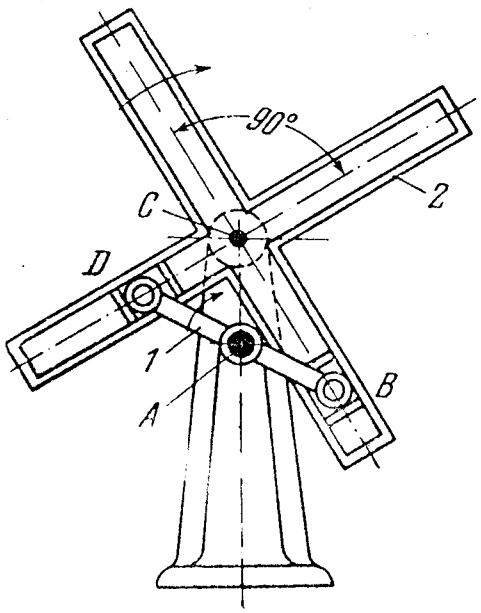
LG 4L




Sliders *2* and *3* rotate about fixed axes *A* and *B*. The angle between the axes of the slots of link *1* equals 90°. Point *E* of slotted link *1* describes a circle. Any other point of link *1*, for instance point *F*, located on circle *b* of radius $\overline{AB}$, describes cardioid *c*. The motion of link *1* is identical to the rolling of movable circle *b* without slipping around fixed circle *a*.

## 937 FOUR-BAR ROTATING-SLOTTED-LINK MECHANISM (MODIFIED SCOTCH YOKE)

LG 4L

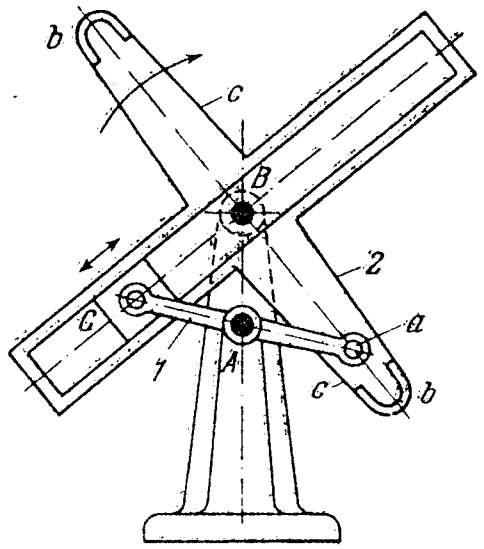



The lengths of the links comply with the condition: $\overline{AB} = \overline{AD} = \overline{AC}$. Link *2* is designed with two perpendicular slots and rotates about fixed axis *C*. Link *2* can be rotated by a single slider. The second slider enables the mechanism to pass through the extreme position (dead point). The mechanism has a transmission ratio between links *1* and *2* equal to

$$i_{12} = \frac{\omega_1}{\omega_2} = 2$$

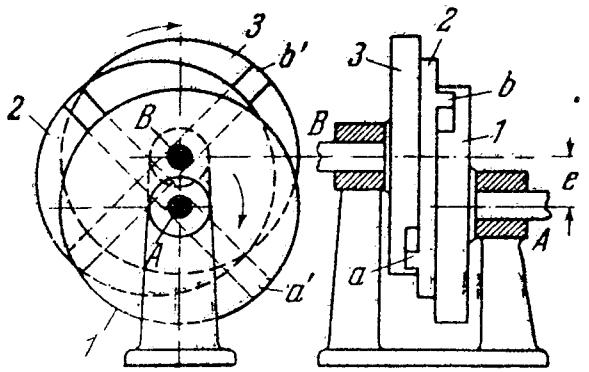
where $\omega_1$ and $\omega_2$ are the angular velocities of links *1* and *2*.

| 938 | FOUR-BAR SLOTTED-LINK MECHANISM WITH SAFETY STOPS | LG. 4L |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AB} = \overline{AC}$. Link *2* is designed as a slotted link with two extensions *c* perpendicular to the slot axis. The ends of the extensions have stops *b*. Link *1* has roller *a*. The mechanism passes through the extreme position (dead point), where point *C* coincides with point *B*, by means of roller *a* which enters stop *b*.

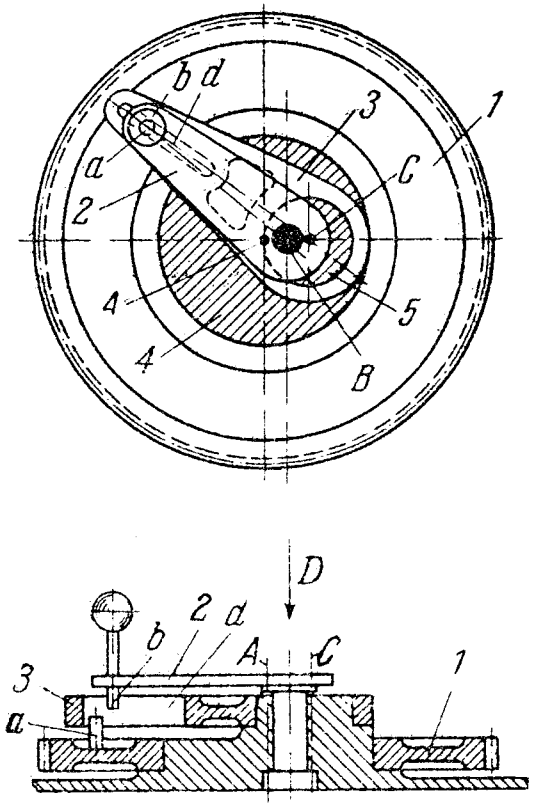
| 939 | FOUR-BAR SLOTTED-LINK MECHANISM OF THE OLDHAM COUPLING | LG 4L |
|---|---|---|




The mechanism is intended for connecting parallel shafts *A* and *B* which are out of line. The transmission ratio $i_{13} = 1$. Rigidly mounted on shafts *A* and *B* are disks *1* and *3* which have grooves *a'* and *b'*. Between the disks is plate *2* having tongues *a* and *b* on its two faces. The tongues are located [illegible] to each other and fit into the grooves *a'* and *b'* of links *1* and *3*. The mechanism transmits uniform motion from one shaft to the other even when the distance *e* between them varies.

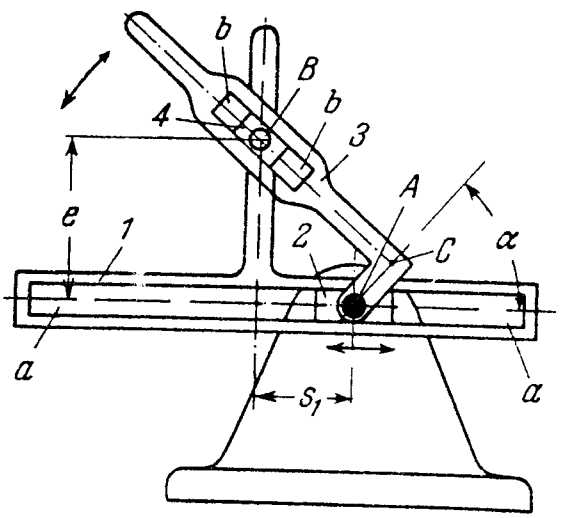
| 940 | FOUR-BAR LINK-GEAR MECHANISM | LG<br>4L |
|---|---|---|

*View facing arrow D*




Link *1*, designed as a gear, rotates about fixed shaft *4* with its centre at point *A*. The gear is rotated by a drive which is not shown. Link *2* rotates about fixed axis *B*. Link *3* rotates about shaft *5* with its centre at point *C*. Rigidly fitted in links *1* and *2* are pins *a* and *b* which slide along radial slot *d* in link *3*. Upon uniform rotation of link *1*, links *2* and *3* rotate nonuniformly, making complete revolutions about centres *B* and *C*.

| 941 | FOUR-BAR OSCILLATING-SLOTTED-LINK MECHANISM | LG 4L |
|---|---|---|



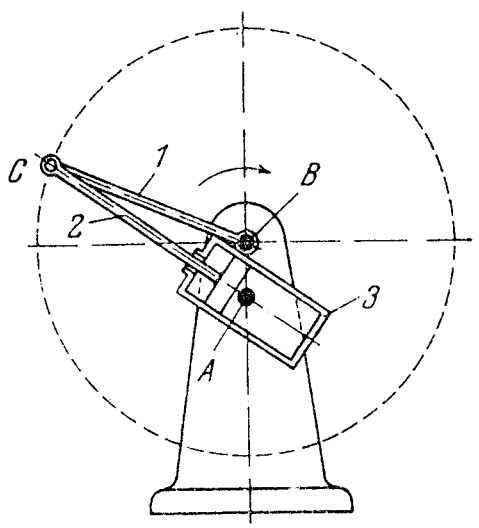

Link *1* has slot *a-a* which moves along fixed slider *2*. Link *3*, turning about fixed axis *A*, has slot *b-b* which moves along slider *4*. Slider *4* is connected by turning pair *B* to link *1*. The axis of slot *b-b* does not pass through point *A*. When link *1* reciprocates, slotted link *3* oscillates about axis *A*. Displacement $s_1$ of link *1* is related to angle $\alpha$ of rotation of link *3* by the equation

$$s_1 = \frac{e \sin \alpha - \overline{AC}}{\cos \alpha}$$

where $\overline{AC}$ is the distance from centre *A* to the axis of slot *b-b*.

## 942 FOUR-BAR SLOTTED-LINK ROTARY CYLINDER MECHANISM

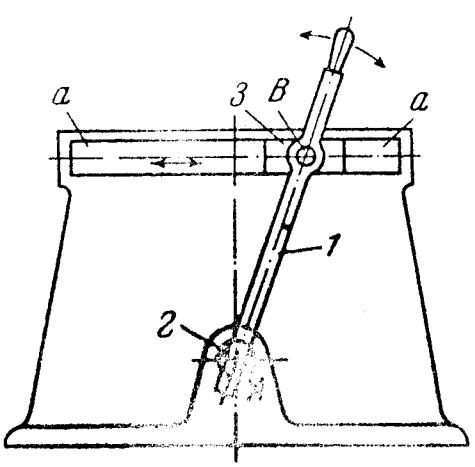
LG 4L




The lengths of the links comply with the condition: $\overline{AB} < \overline{BC}$. Crank *1*, rotating about fixed axis *B*, is connected by turning pair *C* to the piston rod of link 2. When crank *1* rotates, link *2* slides in cylinder *3* and rotates it about fixed axis *A*.

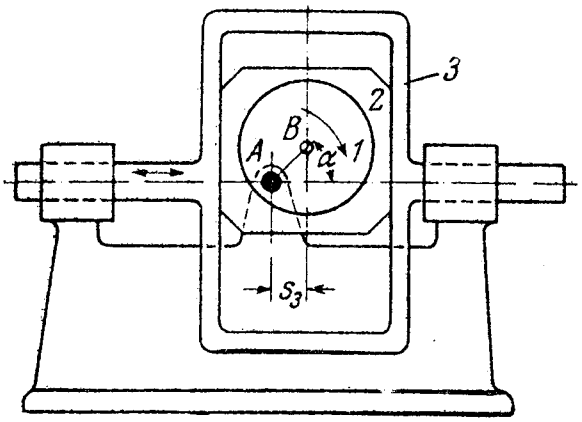
## 943 FOUR-BAR LINK-GEAR MECHANISM WITH A CONNECTING-ROD DRIVE

LG 4L




Connecting rod *1* is connected by turning pair *B* to slider *3* and its other end slides in member *2* which turns about fixed axis *A*. Complex motion of the connecting rod is converted into reciprocation of slider *3* in fixed guiding slot *a-a*.

| 944 | DOUBLE-SLIDER ECCENTRIC-TYPE LINK-GEAR MECHANISM (MODIFIED SCOTCH YOKE) | LG 4L |
|---|---|---|

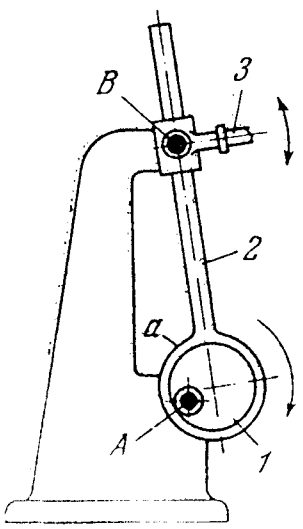



Crank *1* is designed as an eccentric. Slider *2* has a collar which encircles this eccentric. The displacement of link *3* equals

$$s_3 = \overline{AB} \cos \alpha.$$

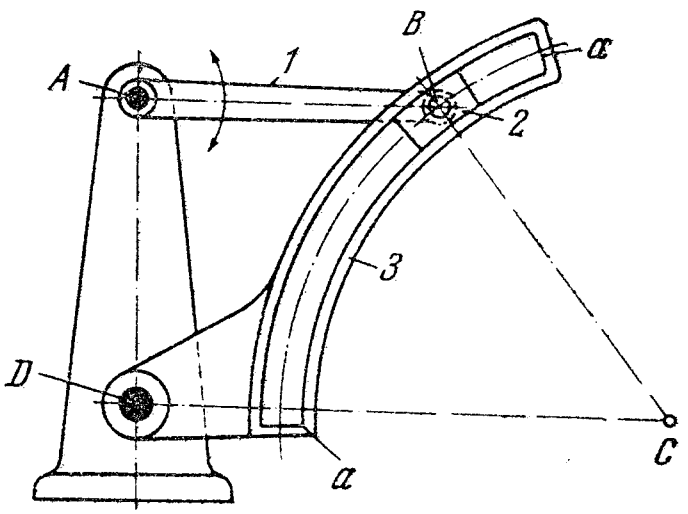
Thus link *3* has simple harmonic motion.

| 945 | LINK-GEAR MECHANISM WITH AN ECCENTRIC | LG 4L |
|---|---|---|




Eccentric *1*, rotating about fixed axis *A*, is encircled by collar *a* of link *2*. Link *2* slides in guiding link *3* which turns about fixed axis *B*. When eccentric *1* rotates, link *3* oscillates.

| 946 | FOUR-BAR CIRCULAR-SLOTTED-LINK MECHANISM | LG 4L |
|---|---|---|

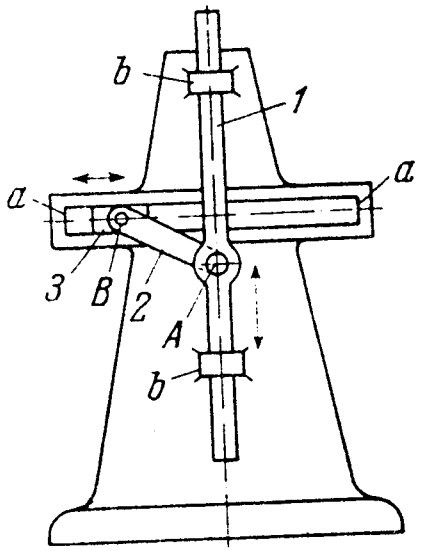



The lengths of the links comply with the conditions:

$$\overline{AB} + \overline{BC} < \overline{AD} + \overline{DC} \text{ and } \overline{AB} < \overline{AD} < \overline{BC} < \overline{DC}.$$

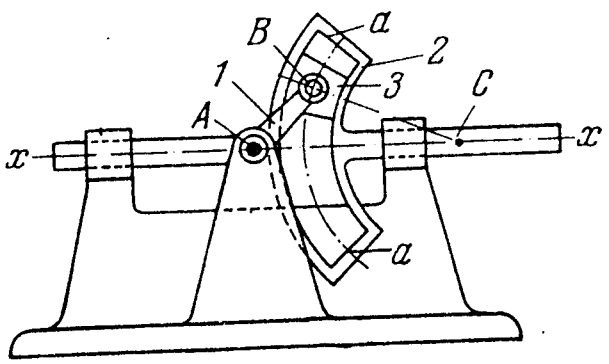
Slider *2* moves along movable circular guiding slot *a-a* of radius $\overline{BC}$ and with its centre at point *C*. When link *1* oscillates about fixed axis *A*, slotted link *3* also oscillates (about fixed axis *D*). The mechanism is equivalent to four-bar double-swing linkage *ABCD* in which link *BC* is the connecting rod, and links *AB* and *DC* are rocker arms.

| 947 | FOUR-BAR RECIPROCATING LINK-GEAR MECHANISM (MODIFIED SCOTCH YOKE) | LG 4L |
|---|---|---|



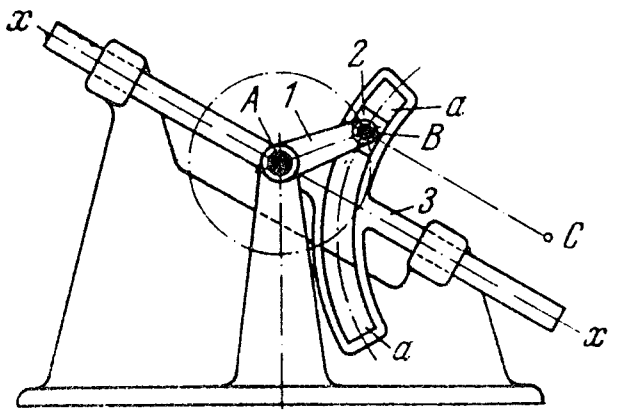

Link *1*, reciprocating in fixed guides *b-b*, is connected by turning pair *A* to link *2*. Slider *3*, connected by turning pair *B* to link *2*, moves along fixed guiding slot *a-a*. The axes of guides *b-b* and guiding slot *a-a* are perpendicular to each other.

| 948 | FOUR-BAR CIRCULAR-SLOTTED-LINK MECHANISM (MODIFIED SCOTCH YOKE) | LG 4L |
|---|---|---|



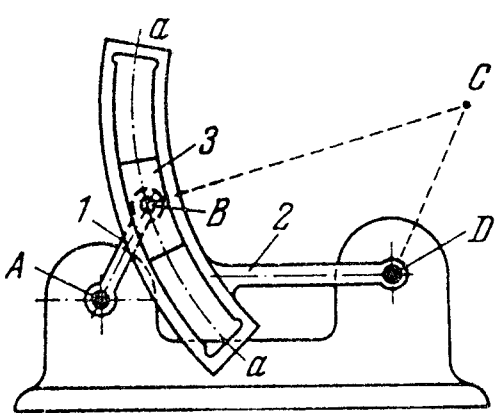

Link *1*, rotating about fixed axis *A*, has pin *B* which fits into slider *3*. Slider *3* moves along movable circular guiding slot *a-a* of radius $\overline{BC}$ and with its centre at point *C*. When link *1* rotates, link *2* reciprocates along axis *x-x*. The mechanism is equivalent to slider-crank linkage *ABC* in which *AB* is the crank, *BC* is the connecting rod and link *2* is the slider.

| 949 | FOUR-BAR CIRCULAR-SLOTTED-LINK MECHANISM (MODIFIED SCOTCH YOKE) | LG 4L |
|---|---|---|




Link *1*, rotating about fixed axis *A*, is connected by turning pair *B* to slider *2* which moves along movable circular guiding slot *a-a* of radius $\overline{BC}$ and with its centre at point *C*. When link *1* rotates, link *3* reciprocates along axis *x-x*. The mechanism is equivalent to offset slider-crank linkage *ABC* in which *AB* is the crank, *BC* is the connecting rod and link *3* is the slider.

| 950 | FOUR-BAR CIRCULAR-SLOTTED-LINK MECHANISM | LG 4L |
|---|---|---|



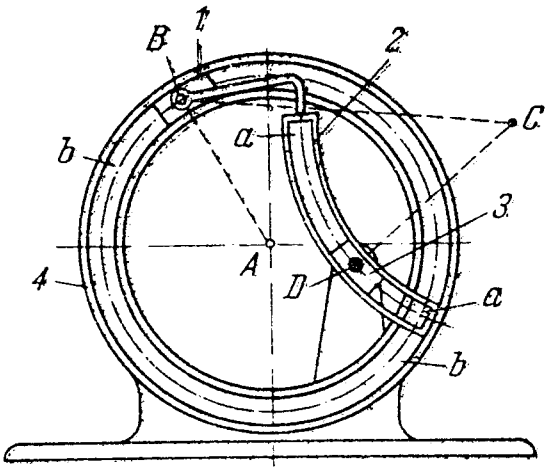

The lengths of the links comply with the conditions:

$$\overline{AB} + \overline{BC} < \overline{DC} + \overline{AD} \text{ and}$$

$$\overline{AB} < \overline{DC} < \overline{AD} < \overline{BC}.$$

Link *3* is designed as a circular slider which moves along movable circular guiding slot *a-a* of radius $\overline{BC}$ and with its centre at point *C*. When crank *1* rotates about fixed axis *A*, slotted link *2* oscillates about fixed axis *D*. The mechanism is equivalent to four-bar crank and rocker-arm linkage *ABCD* in which *AB* is the crank, *BC* is the connecting rod and *DC* is the rocker arm.

| 951 | FOUR-BAR CIRCULAR-SLOTTED-LINK MECHANISM | LG 4L |
|---|---|---|

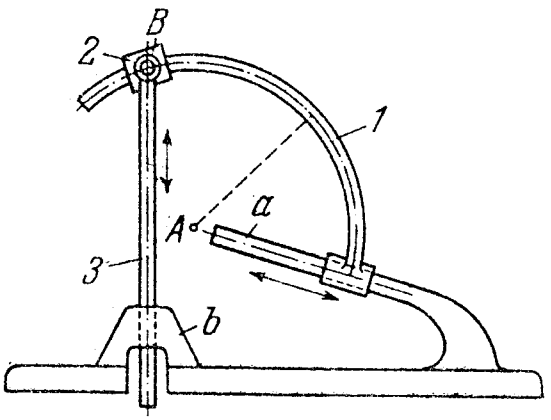



The lengths of the links comply with the conditions:

$$\overline{AB} + \overline{BC} > \overline{DC} + \overline{AD} \text{ and } \overline{AD} < \overline{AB} < \overline{DC} < \overline{BC}.$$

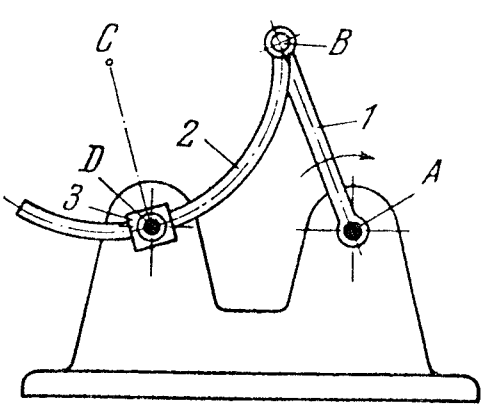
Slider *1* moves along fixed annular guiding slot *b-b* of radius $\overline{AB}$ and with its centre at point *A*. Slotted link *2* has circular guiding slot *a-a* of radius $\overline{DC}$ and with its centre at point *C*. Link *2* moves along slider *3* which rotates about fixed axis *D*. When slider *1* moves around slot *b-b* of link *4*, slotted link *2* has a complex motion and slider *3* rotates about axis *D*. The mechanism is equivalent to four-bar drag-link mechanism *ABCD* in which *AB* and *CD* are cranks and *BC* is the connecting rod.

| 952 | FOUR-BAR RECIPROCATING-CIRCULAR-SLIDING-LINK MECHANISM | LG 4L |
|---|---|---|



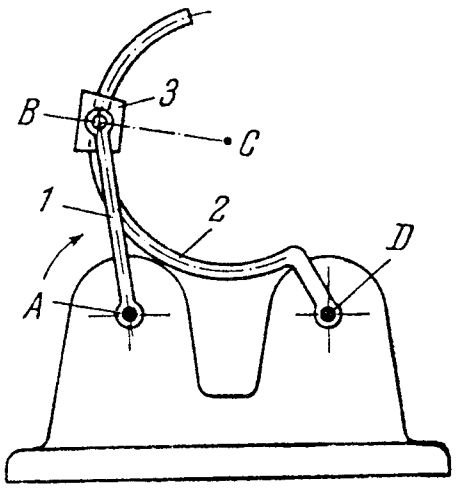

Sliding link *1*, moving along fixed guide *a*, is designed as a circular link of radius $\overline{AB}$ and with its centre at point *A*. Slider *2*, connected by turning pair *B* to rod *3*, moves along circular link *1*. Rod *3* slides in fixed guide *b*. When circular link *1* slides along guide *a*, rod *3* reciprocates in guide *b*.

| 953 | FOUR-BAR OSCILLATING-CIRCULAR-SLIDING-LINK MECHANISM | LG 4L |
|---|---|---|



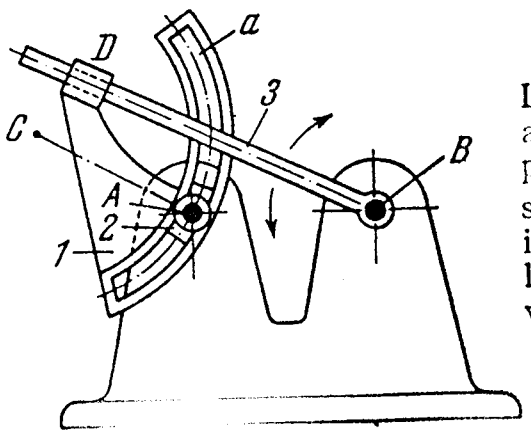

Link *1*, turning about fixed axis *A*, is connected by turning pair *B* to circular sliding link *2* of radius $\overline{CD}$ and with its centre at point *C*. Link *2* moves in circular slider *3* which turns about fixed axis *D*. When link *1* is turned, link *3* also turns about axis *D*. The mechanism is equivalent to four-bar linkage *ABCD*.

| 954 | FOUR-BAR CIRCULAR-SLIDING-LINK MECHANISM | LG 4L |
|---|---|---|



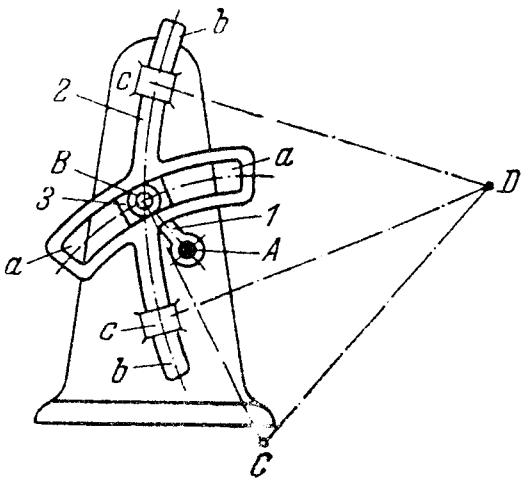

Link *1*, rotating about fixed axis *A*, is connected by turning pair *B* to slider *3*. Slider *3* moves along circular sliding link *2* of radius $\overline{CB}$ and with its centre at point *C*. When link *1* rotates about axis *A*, sliding link *2* rotates about fixed axis *D*. The mechanism is equivalent to four-bar linkage *ABCD*.

| 955 | FOUR-BAR CIRCULAR-SLOTTED-LINK MECHANISM WITH COMPLEX SLOTTED-LINK MOTION | LG 4L |
|---|---|---|



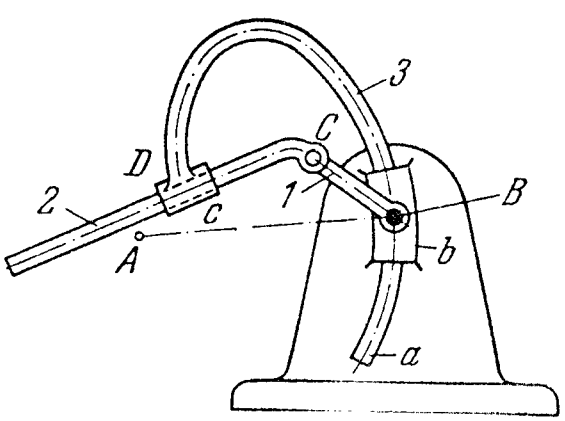

Link *3*, turning about fixed axis *B*, is connected by sliding pair *D* to link *1* having circular slot *a* of radius $\overline{CA}$ and with its centre at point *C*. The circular slot moves along slider *2* which turns about fixed axis *A*.

| 956 | FOUR-BAR DOUBLE CIRCULAR-SLOTTED-LINK MECHANISM (MODIFIED SCOTCH YOKE) | LG 4L |
|---|---|---|



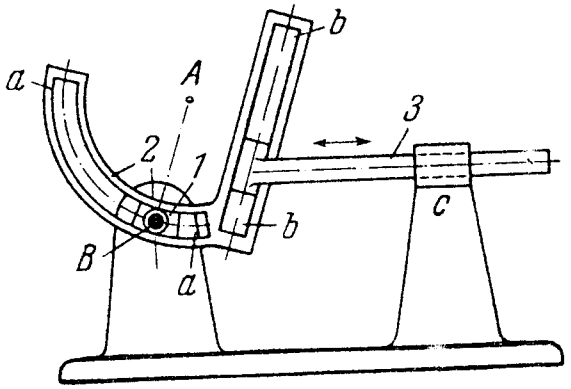

Crank *1*, rotating about fixed axis *A*, is connected by turning pair *B* to slider *3*. Slider *3* moves along circular guiding slot *a-a* of radius $\overline{CB}$ and with its centre at point *C*. Circular slot *a-a* belongs to link *2* which is cross-shaped and has extensions *b* which slide in fixed circular guides *c-c* of radius $\overline{DB}$ and with their centre at point *D*. The mechanism is equivalent to four-bar linkage *ABCD*.

| 957 | FOUR-BAR CIRCULAR-SLIDING-LINK MECHANISM | LG 4L |
|---|---|---|



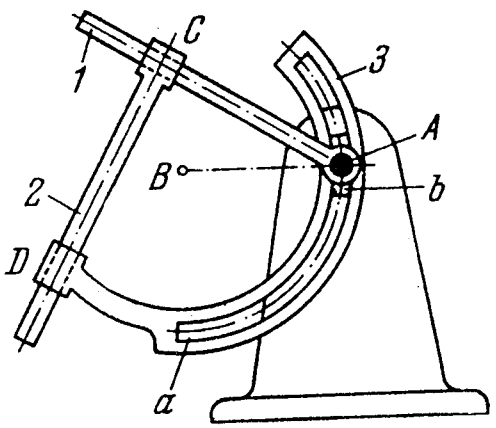

Crank *1*, rotating about fixed axis *A*, is connected by turning pair *C* to link *2*. Link *3* is connected by sliding pair *D* to link *2*. Link *3* is designed as a circular link *a* of radius $\overline{AB}$ and with its centre at point *A*. Link *3* slides in fixed circular guide *b*. Link *2* slides along straight guide *c* of link *3*.

| 958 | FOUR-BAR CIRCULAR-SLOTTED-LINK MECHANISM | LG 4L |
|---|---|---|



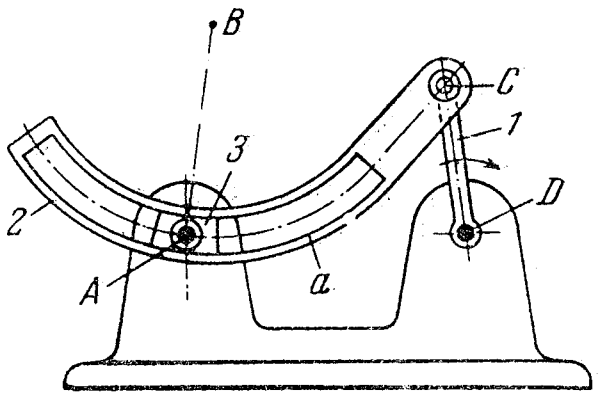

Bar *3* slides in fixed guide *c*. Link *2* has straight guiding slot *b-b* and circular guiding slot *a-a* of radius $\overline{AB}$ and with its centre at point *A*. Slider *1* turns about fixed axis *B*. Circular slot *a-a* of link *2* moves along slider *1*. Bar *3* slides in straight guiding slot *b-b* of link *2*. Motion of link *2* leads to reciprocation of rod *3* in fixed guide *c*. The mechanism is equivalent to a reciprocating-slotted-link mechanism.

| 959 | FOUR-BAR CIRCULAR-SLOTTED-LINK MECHANISM | LG 4L |
|---|---|---|



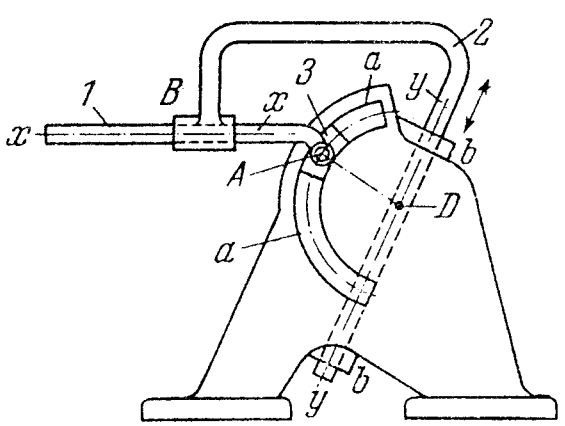

Link *1*, rotating about fixed axis *A*, is connected by sliding pair *C* to link *2* which, in turn, is connected by sliding pair *D* to link *3*. Link *3* has circular guiding slot *a* of radius $\overline{BA}$ and with its centre at point *B*. Slot *a* moves along fixed slider *b* of the upright. When link *1* turns, link *2* slides along it, and link *3* moves along slider *b*. Thus link *3* oscillates about point *B*. The angular velocities of all the links are equal.

| 960 | FOUR-BAR CIRCULAR-SLOTTED-LINK MECHANISM | LG 4L |
|---|---|---|



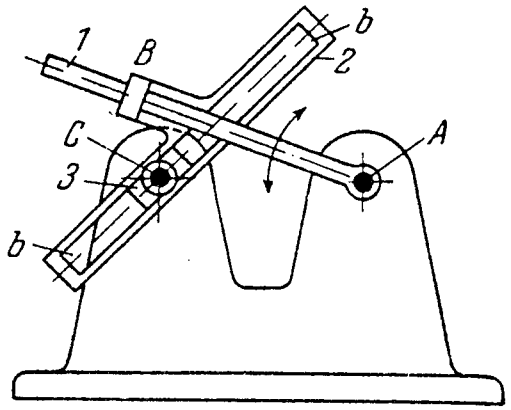

Link *1*, rotating about fixed axis *D*, is connected by turning pair *C* to link *2* having circular slot *a* of radius $\overline{BA}$ and with its centre at point *B*. Slider *3* turns about fixed axis *A*. When crank *1* rotates, slotted link *2* moves along slider *3*. The mechanism is equivalent to four-bar linkage *ABCD*.

| 961 | FOUR-BAR TRANSLATORY-SLIDING-LINK MECHANISM | LG 4L |
|---|---|---|



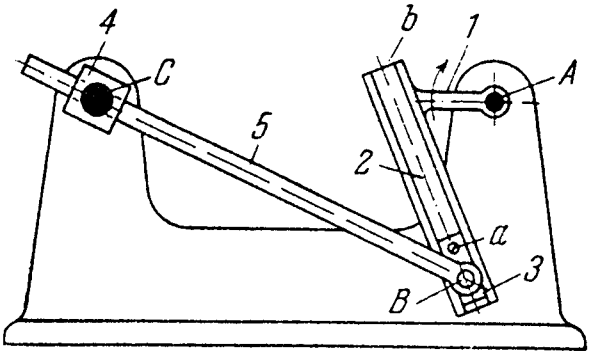

Link *2* sliding in fixed guides *b-b*, is connected by sliding pair *B* to link *1* which, in turn, is connected by turning pair *A* to circular slider *3*. Slider *3* moves along circular slot *a-a* of radius $\overline{DA}$ and with its centre at point *D*. When slider *3* moves along slot *a-a*, link *2* reciprocates in guides *b-b*. Link *1* participates in two translatory motions simultaneously: along axes *x-x* and *y-y*.

| 962 | FOUR-BAR ANGLE-TYPE SLOTTED-LINK MECHANISM | LG 4L |
|---|---|---|



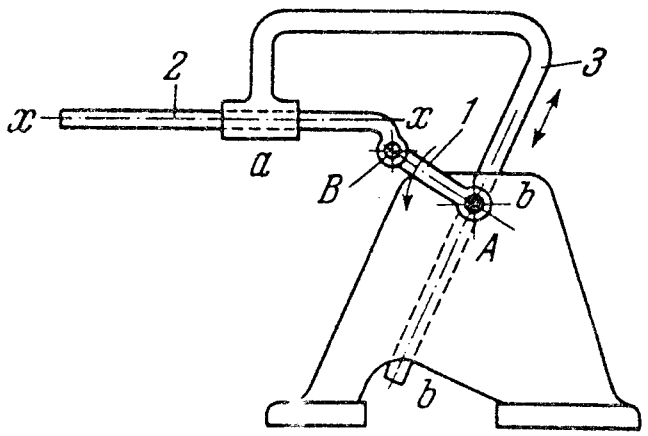

Link *1* turns about fixed axis *A* and is connected by sliding pair *B* to angle-type slotted link *2* having slot *b-b*. Slider *3* rotates about fixed axis *C*. When link *1* oscillates, link *2* moves along slider *3*. The angular velocities of all the links are equal.

| 963 | FOUR-BAR VARIABLE-CRANK MECHANISM | LG 4L |
|---|---|---|



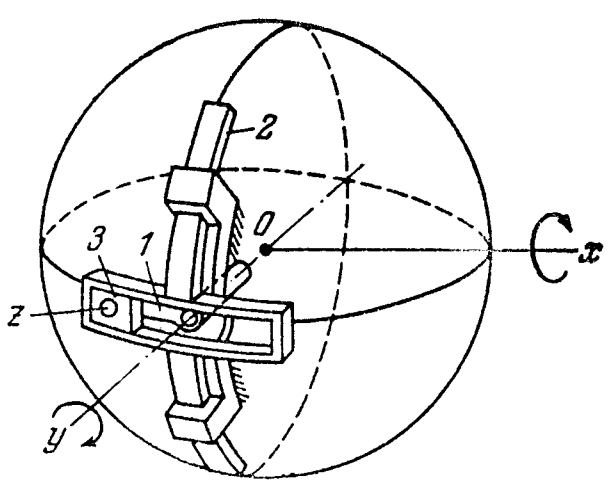

Link *1*, rotating about fixed axis *A*, is connected by turning pair *B* to link *5*. Link *5* moves in slider *4* which turns about fixed axis *C*. Straight slotted member *b* is rigidly secured to link *1*. By means of screw *a* slider *3* can be clamped at various positions along the axis of slotted member *b*. This varies length $\overline{AB}$ of crank *1*.

| 964 | FOUR-BAR TRANSLATORY-SLIDING-LINK MECHANISM | LG 4L |
|---|---|---|



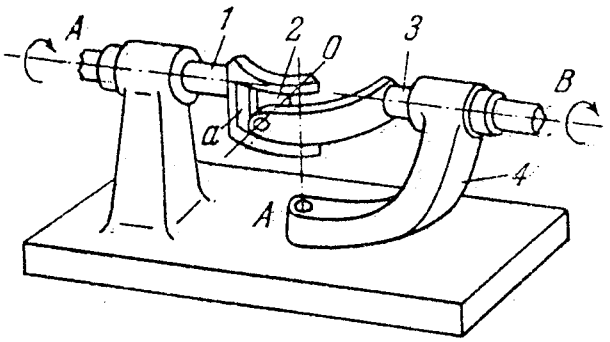

Link *1*, rotating about fixed axis *A*, is connected by turning pair *B* to link *2*. Link *3* slides along fixed guides *b-b* and along axis *x-x* of link *2*. When crank *1* rotates, link *2* has a circular translatory motion.

| 965 | FOUR-BAR SPHERICAL SLOTTED-LINK MECHANISM (MODIFIED SCOTCH YOKE) | LG 4L |
|---|---|---|



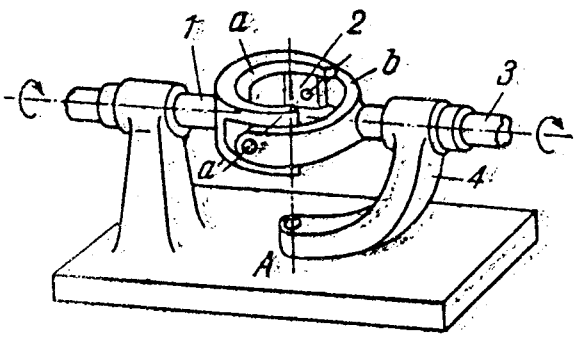

Crank *1*, rotating about axis *y*, is connected by a turning pair to slider *3*. Axis *z* of the crankpin intersects axis *y* at point *O*. Link *2* has a slotted member whose axis is curvilinear and coincides with an arc of a great circle of the sphere. Link *2* reciprocates in fixed guides whose axis coincides with an arc of the great circle of the sphere, perpendicular to axis *x*. Link *1* rotates and link *2* oscillates about mutually perpendicular axes *y* and *x*.

| 966 | FOUR-BAR SLOTTED-LINK SPHERICAL MECHANISM | LG 4L |
|---|---|---|



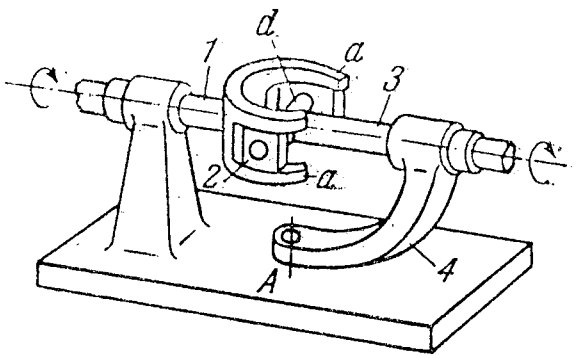

Link *1* has circular guide *a* with its centre at point *O*. Link *3* is connected by a turning pair to link *2* which is designed as a prismatic slider fitting in guide *a*. When bracket *4* is put into various positions by turning it about fixed axis *A* and clamping it, rotation can be transmitted from link *1* through link *2* to link *3*, rotating about fixed axis *B*, under the condition that the axes of all the turning pairs and of the circular guide intersect at single point *O*. The mechanism transmits rotation from shaft *1* to shaft *3* at various angles of intersection of their axes at point *O*.

| 967 | FOUR-BAR SLOTTED-LINK SPHERICAL MECHANISM | LG 4L |
|---|---|---|



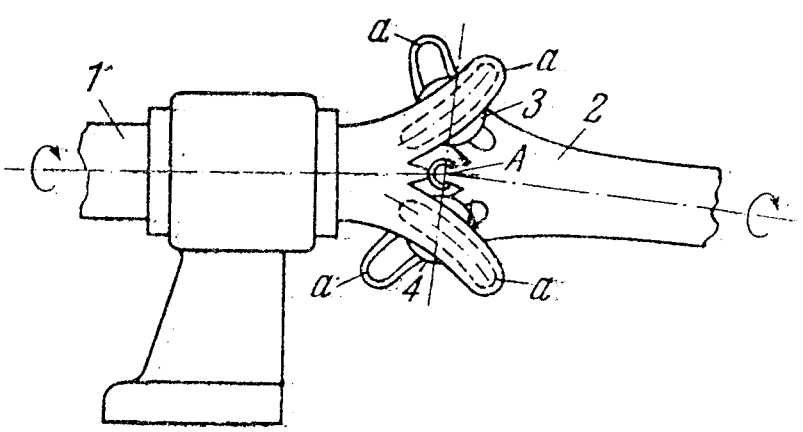

Link *1* has two circular guides *a*. Link *3* has fork *b* at its end. Link *2* is designed as two separate prismatic sliders fitting in guides *a*. When bracket *4* is put into various positions by turning it about fixed axis *A* and clamping it, rotation can be transmitted from link *1* to link *3* under the condition that the axes of all the turning pairs and of the circular guides intersect at a single point. The mechanism transmits rotation from shaft *1* to shaft *3* at various angles of intersection of their axes at a constant point.

| 968 | FOUR-BAR SLOTTED LINK SPHERICAL MECHANISM | LG 4L |
|---|---|---|



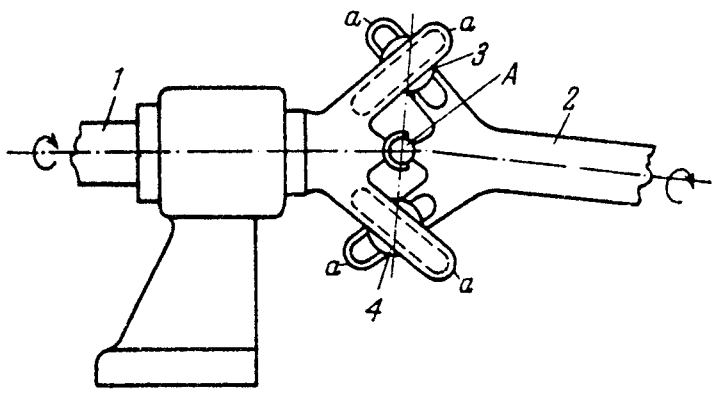

Link *1* has two circular guides *a*. Link *2* is designed as two sliders fitting in guides *a* and turning about the axis of pin *d*. When bracket *4* is put into various positions by turning it about fixed axis *A* and clamping it, rotation can be transmitted from link *1* to link *3* under the condition that the axes of all the turning pairs and of the circular guides intersect at a single point. The mechanism transmits rotation from shaft *1* to shaft *3* at various angles of intersection of their axes at a constant point.

| 969 | LINK-GEAR SPHERICAL MECHANISM | LG 4L |
|---|---|---|



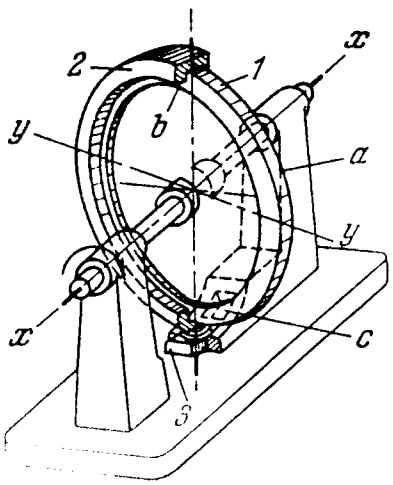

Link *1* is connected by spherical pair *A* to link *2*. Links *1* and *2* have circular guides *a*. Balls *3* and *4* roll along these guides. Rotation is transmitted from shaft *1* to shaft *2* under the condition that their axes intersect at the single common point *A*.

| 970 | LINK-GEAR SPATIAL SYMMETRICAL MECHANISM | LG 41. |
|---|---|---|




Link *1* is connected by spherical pair *A* to link *2*. Links *1* and *2* have radial guides *a* which are of circular cross section and in which balls *3* and *4* roll. Rotation is transmitted from shaft *1* to shaft *2* under the condition that their axes intersect at the single common point *A*.

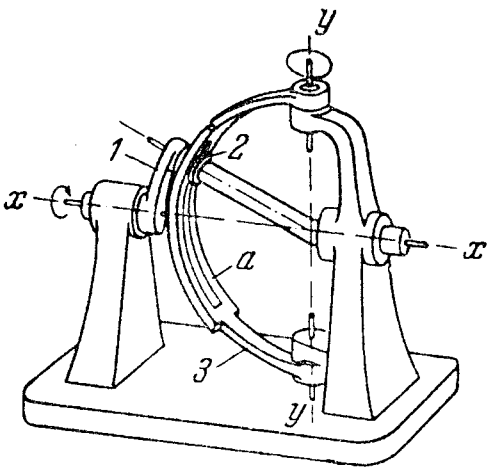
| 971 | FOUR-BAR SLOTTED-LINK SPHERICAL MECHANISM | LG 4L |
|---|---|---|




Disk *1* whose plane makes an angle not equal to 90° with axis *x-x* rotates about fixed axis *x-x*. The turning pair connecting links *1* and *2* is designed as rim *a* sliding in groove *b*. Link *2* is connected by a turning pair to link *3* which is designed as a circular slider that moves in fixed circular guide *c*. When disk *1* rotates about axis *x-x*, it slides in the groove of annular slotted link *2*. Link *2* turns with respect to slider *3* which oscillates about axis *y-y*. These motions take place under the condition that the axes of all the kinematic pairs intersect at a single point.

## 972 FOUR-BAR SLOTTED-LINK SPHERICAL MECHANISM

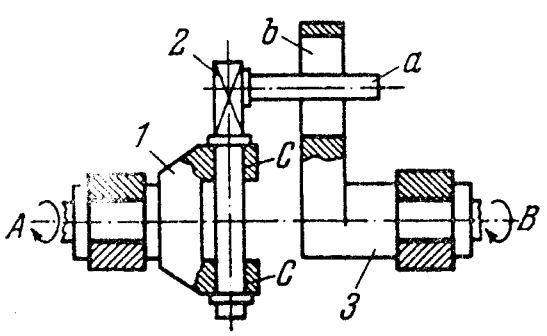
LG 4L




Crank *1*, rotating about fixed axis *x-x*, is connected by a turning pair to link *2*. The kinematic pair connecting links *2* and *3* is designed as circular slider *2* and slotted link *3* with slot *a*. Link *3* turns about fixed axis *y-y*. When crank *1* rotates about axis *x-x*, slider *2* moves in slot *a* of slotted link *3* which oscillates about axis *y-y* under the condition that the axes of all the turning pairs intersect at a single point.

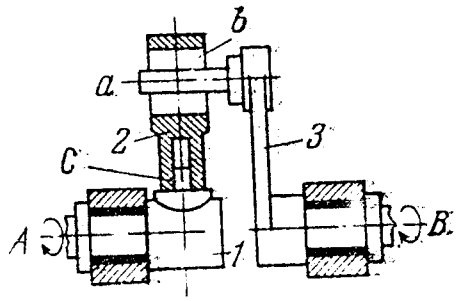
## 973 FOUR-BAR LINK-GEAR SPATIAL MECHANISM WITH A FOUR-MOTION KINEMATIC PAIR

LG 4L



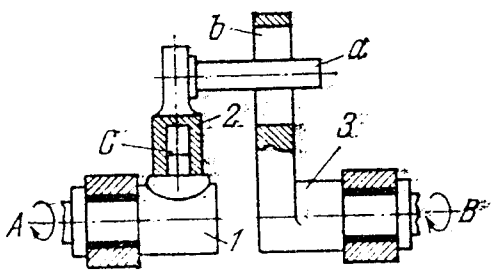

Link *1*, rotating about fixed axis *A*, is connected by turning pair C to link *2*. Pin *a* of link *2* slides in slot *b* of slotted member 3 which rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

| 974 | FOUR-BAR LINK-GEAR SPATIAL MECHANISM WITH A FOUR-MOTION KINEMATIC PAIR | LG 4L |
|---|---|---|



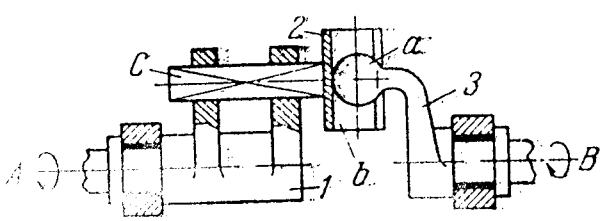

Link *1*, rotating about fixed axis *A*, is connected by turning pair *C* to slotted link *2*. Pin *a* of link *3*, rotating about fixed axis *B*, slides in slot *b* of link *2*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

| 975 | FOUR-BAR LINK-GEAR SPATIAL MECHANISM WITH A FOUR-MOTION KINEMATIC PAIR | LG 4L |
|---|---|---|



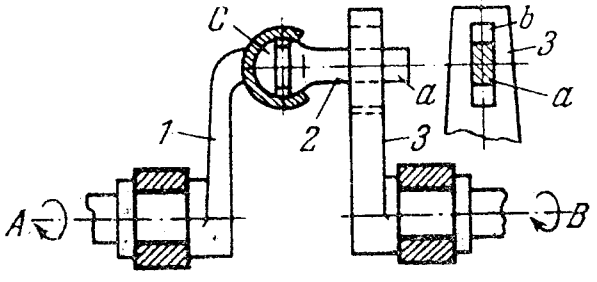

Link *1*, rotating about fixed axis *A*, is connected by turning pair *C* to link *2*. Pin *a* of link *2* enters slot *b* of slotted link *3* which rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

| 976 | FOUR-BAR LINK-GEAR SPATIAL MECHANISM WITH A FOUR-MOTION KINEMATIC PAIR | LG 4L |
|---|---|---|



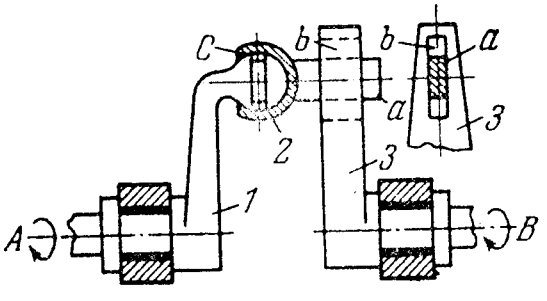

Link *1*, rotating about fixed axis *A*, is connected by sliding pair *C* to link *2*. Link *3*, rotating about fixed axis *B*, has spherical surface *a* at its left end which slides along hollow cylindrical surface *b* of link *2*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*

| 977 | FOUR-BAR LINK-GEAR SPATIAL MECHANISM WITH A THREE-MOTION KINEMATIC PAIR | LG 4L |
|---|---|---|



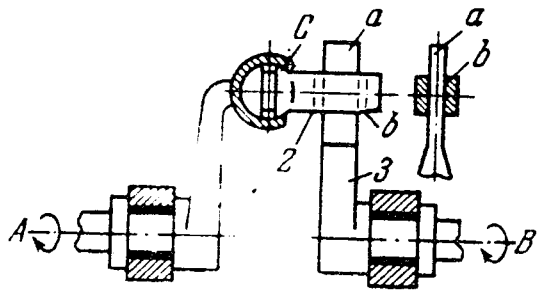

Link *1*, rotating about fixed axis *A*, is connected by kinematic pair *C* to link *2*. Pair *C* permits two turning motions about two mutually perpendicular axes. Rectangular shank *a* of link *2* slides in slot *b* of slotted link *3* which rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

| 978 | FOUR-BAR LINK-GEAR SPATIAL MECHANISM WITH A THREE-MOTION KINEMATIC PAIR | LG 4L |
|---|---|---|



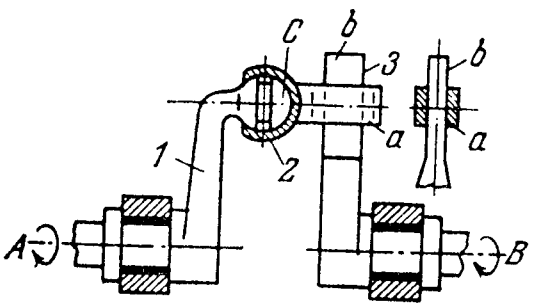

Link *1*, rotating about fixed axis *A*, is connected by kinematic pair *C* to link *2*. Pair *C* permits two turning motions about two mutually perpendicular axes. Rectangular shank *a* of link *2* slides in slot *b* of slotted link *3* which rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

| 979 | FOUR-BAR LINK-GEAR SPATIAL MECHANISM WITH A THREE-MOTION KINEMATIC PAIR | LG 4L |
|---|---|---|



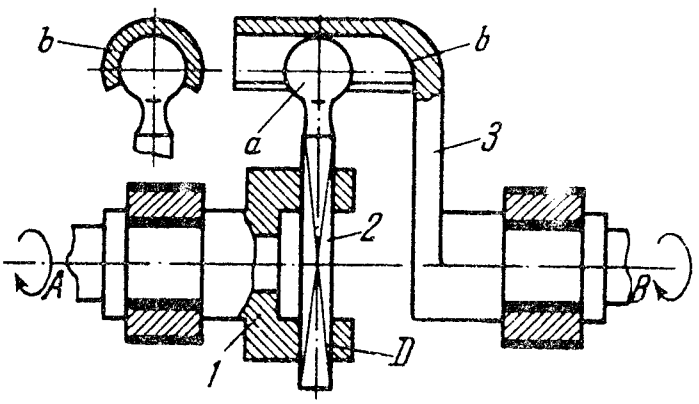

Link *1*, rotating about fixed axis *A*, is connected by kinematic pair *C* to link *2*. Pair *C* permits two turning motions about two mutually perpendicular axes. Link *3*, rotating about fixed axis *B*, has shank *a* which enters slot *b* of link *2*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

| 980 | FOUR-BAR LINK-GEAR SPATIAL MECHANISM WITH A THREE-MOTION KINEMATIC PAIR | LG 4L |
|---|---|---|



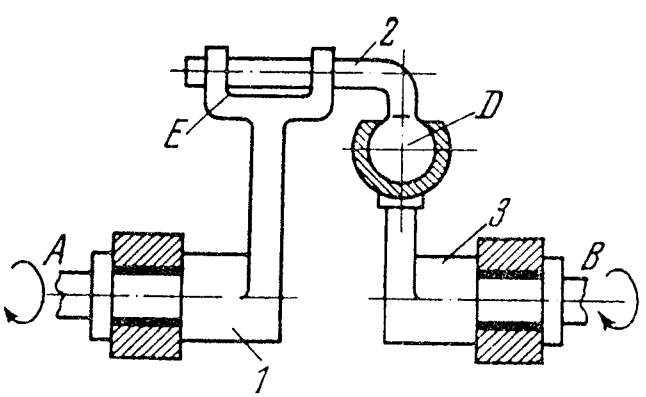

Link *1*, rotating about fixed axis *A*, is connected by kinematic pair *C* to link *2*. Pair *C* permits two turning motions about two mutually perpendicular axes. Link *3*, rotating about fixed axis *B*, has shank *b* which enters slot *a* of link *2*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

| 981 | FOUR-BAR LINK-GEAR SPATIAL MECHANISM WITH A FOUR-MOTION KINEMATIC PAIR | LG 4L |
|---|---|---|



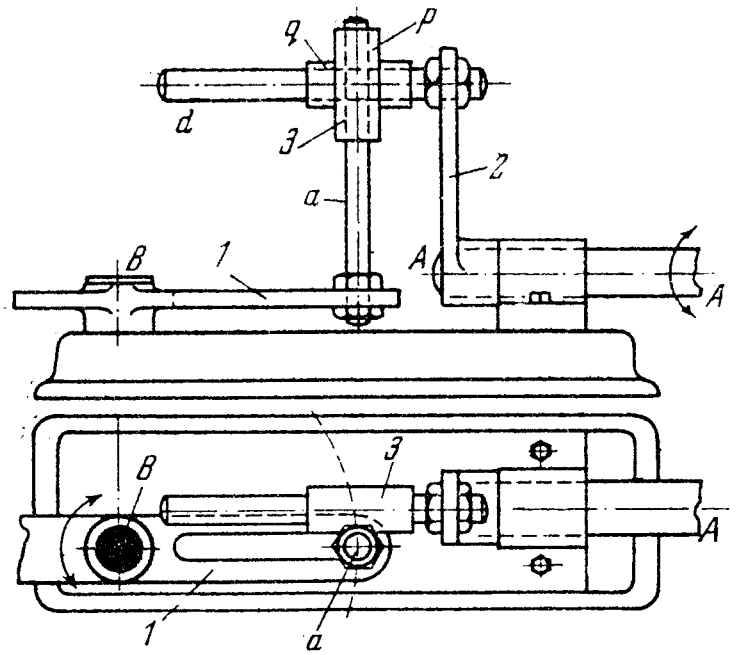

Link *1*, rotating about fixed axis *A*, is connected by sliding pair *D* to link *2* which, in turn, is connected by a four-motion pair to link *3*. The four-motion pair consists of spherical surface *a* of link *2* which contacts hollow cylindrical surface *b* of link *3*. Link *3* rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

| 982 | FOUR-BAR LINK-GEAR SPATIAL MECHANISM WITH CYLINDRICAL AND SPHERICAL PAIRS | LG 4L |
|---|---|---|



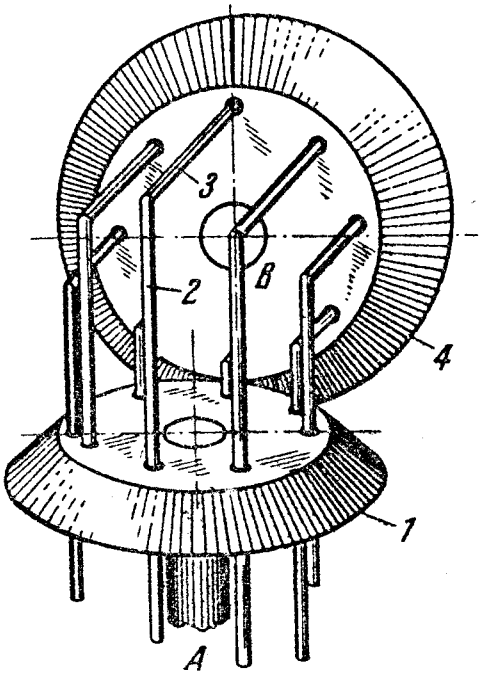

Link *1*, rotating about fixed axis *A*, is connected by cylindrical turning and sliding pair *E* to link *2*. Link *2* is connected by spherical pair *D* to link *3* which rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

| 983 | FOUR-BAR SLIDING-LINK SPATIAL MECHANISM | LG 4L |
|---|---|---|



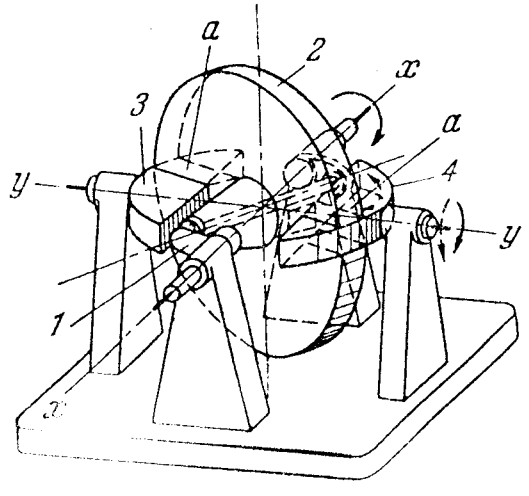

Link *1*, turning about fixed axis *B*, has adjustable pin *a* which slides in guide *p* of cross-shaped link *3*. Link *2*, rotating about fixed axis *A*, has adjustable pin *d* which slides in guide *q* of link *3*. When link *1* is turned, cross-shaped link *3* slides along pins *a* and *d*. This turns shaft *A* through a certain angle. Thus, when link *1* oscillates about vertical axis *B*, link *2* oscillates about horizontal axis *A*. The angle of oscillation of link *2* can be varied by adjusting pins *a* and *d* along the slots in links *1* and *2*.

| 984 | LINK-GEAR ANGULAR DRIVE MECHANISM | LG 4L |
|---|---|---|



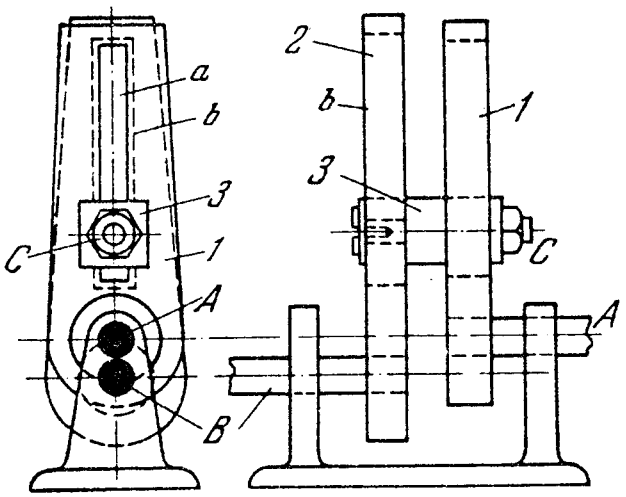

Links *1* and *4* are tapered wheels which are connected by several bent rods *2* and *3*. The wheels are connected by turning and sliding pairs to the rods. Shafts *A* and *B*, on which wheels *1* and *4* are rigidly mounted, are connected by turning pairs to a bracket which is not shown.

| 985 | FOUR-BAR SLOTTED-LINK SPHERICAL MECHANISM | LG 4L |
|---|---|---|




Crank *1* rotates about fixed axis *x-x* and is connected by a turning pair to disk *2*. Disk *2* slides with its slots *a* along segments *3* and *4* which turn about fixed axis *y-y*. When crank *1* rotates about axis *x-x*, segments *3* and *4* oscillate about axis *y-y* under the condition that the axes of all the kinematic pairs intersect at a single point.

| 986 | FOUR-BAR LINK-GEAR MECHANISM WITH VARIABLE TRANSMISSION RATIO | LG 4L |
|---|---|---|

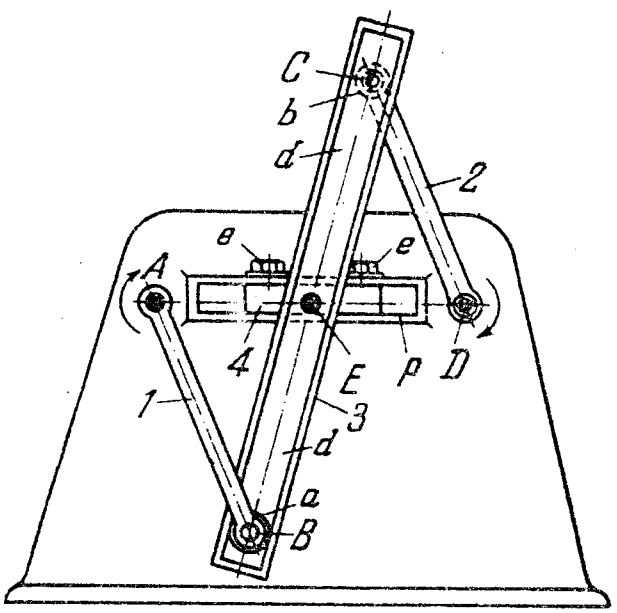



Link *1*, rotating about fixed axis *A*, is connected by turning pair *C* to slider *3* which slides along slot *b* of link *2*. Link *2* rotates about fixed axis *B*. Slider *3* can be clamped at various positions in slot *a*. When crank *1* rotates about axis *A*, slotted link *2* rotates about axis *B* so that the average transmission ratio between links *1* and *2* equals

$$i_{12} = \frac{\omega_1}{\omega_2} = 1.$$

Since axis *B* is parallel to but out of line with axis *A*, in one revolution of crank *1* at constant angular velocity, slotted link *2* also makes one revolution but at variable angular velocity. The angular velocity of slotted link *2* can be changed by adjusting slider *3* along slot *a* of crank *1* and clamping the slider.

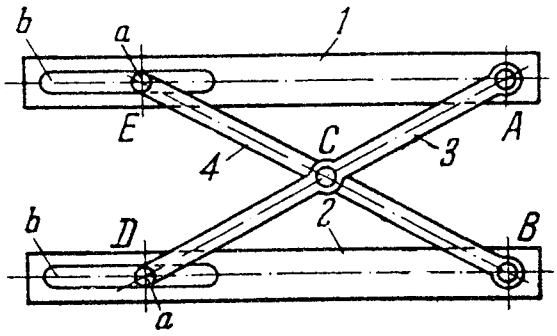
| 987 | FOUR-BAR LINK-GEAR MECHANISM WITH VARIABLE TRANSMISSION RATIO | LG 4L |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AB} = \overline{DC}$. Cranks *1* and *2* rotate about fixed axes *A* and *D*. At points *B* and *C* the cranks have rollers *a* and *b* which slide and roll in the slots *d* of double slotted link *3*. Slotted link *3* turns about fixed axis *E* of slider *4* which can be adjusted and rigidly clamped in fixed guide *p* by screws *e*. The rotation of driving crank *1* is transmitted through rollers *a* and *b*, and slotted link *3* to driven crank *2*. In the position shown, the distance $\overline{AE} = \overline{ED}$. In this case, rotation is transmitted from link *1* to link *2* with the constant transmission ratio $i_{12} = \frac{\omega_1}{\omega_2} = 1$. If slider *4* is shifted (and clamped), then the average transmission ratio will remain the same, the transmission ratio $i_{12}$ being variable within a revolution.

## 988 LINK-GEAR MECHANISM FOR PARALLEL RULES

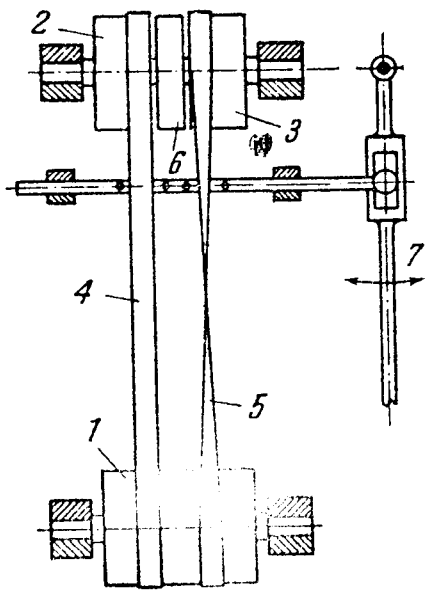
LG 4L




The lengths of the links comply with the condition: $\overline{AC} = \overline{CB} = \overline{CE} = \overline{CD}$. Links *3* and *4* have pins *a* that slide in slots *b* of rules *2* and *1*. The slot width equals the pin diameter. In any fixed position of rule *2* the edge of rule *1* is parallel to the edge of rule *2*.

## 989 LINK-GEAR SHIFTER MECHANISM FOR BELT DRIVES

LG 4L

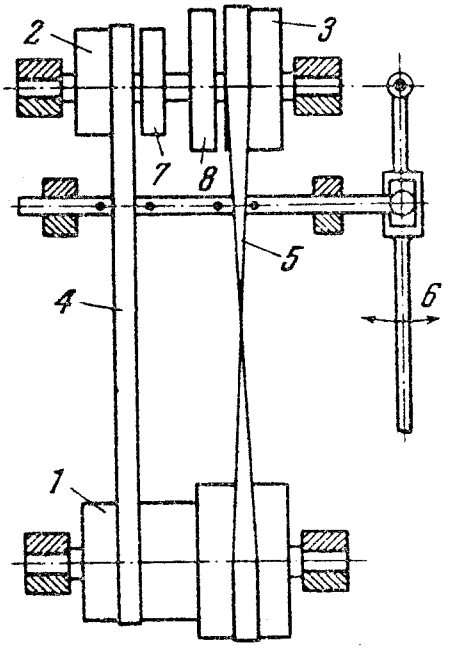



Driving pulley *1* is connected to idle pulleys *2* and *3* by open belt *4* and crossed belt *5*. Either one of the belts is shifted to driven working pulley *6* by means of link-gear belt shifter *7*. The transmission ratios of the open and crossed belt drives are the same but of opposite sign (reversing the rotation of pulley *6*).

990

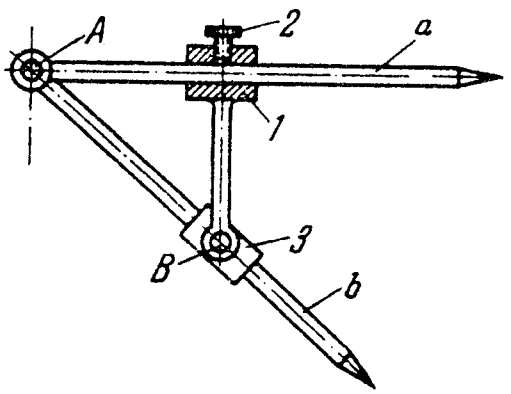
# LINK-GEAR SHIFTER MECHANISM FOR BELT DRIVES

LG 4L



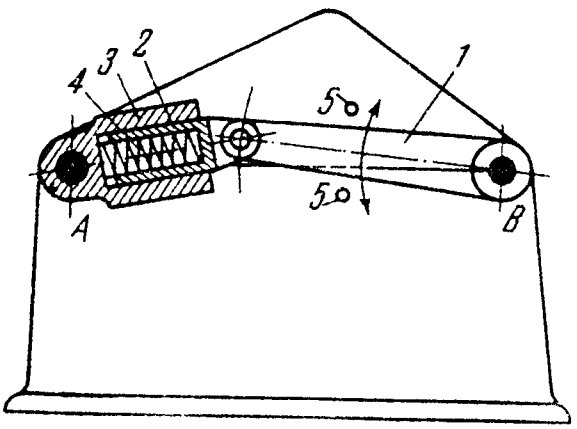

Stepped driving pulley *1* is connected to idle pulleys *2* and *3* by open belt *4* and crossed belt *5*. When the lever of link-gear belt shifter *6* is moved to the right, open belt *4* is shifted to working pulley *7* and the driven shaft on which pulley *7* is rigidly mounted begins to rotate in the same direction as driving pulley *1*. When the lever of shifter *6* is moved to the left, crossed belt *5* connects working pulley *8* to driving pulley *1*, and driven pulley *8* together with its shaft begin to rotate in the opposite direction to driving pulley *1*. The transmission ratios for direct and reverse rotation of the belt drive differ in both magnitude and sign.

| 991 | LINK-GEAR MECHANISM FOR DIVIDERS | LG, 4L |
|---|---|---|




Link *1* slides along leg *a* of the dividers. Leg *a* turns about axis *A*. Slider *3*, moving along leg *b* of the dividers, is connected by turning pair *B* to link *1*. When link *1* is moved along leg *a*, link *3* moves along leg *b* thereby spreading or contracting the legs of the dividers. The position of slider *1* is fixed by clamping with screw *2*.

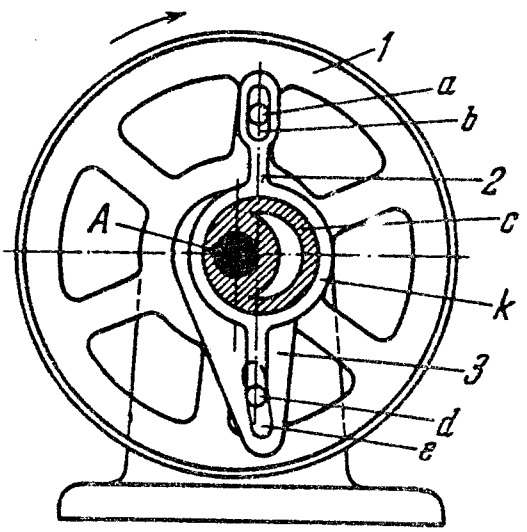
| 992 | FOUR-BAR SPRING-ACTUATED TUMBLER MECHANISM | LG 4L |
|---|---|---|




The pressure exerted by spring *4* on slider *2* turns links *3* and *1*, connected by a turning pair, about fixed axes *A* and *B*. Link *1* may occupy one of the two positions determined by pins *5*.

# 993 LINK-GEAR PULLEY-DRIVE MECHANISM

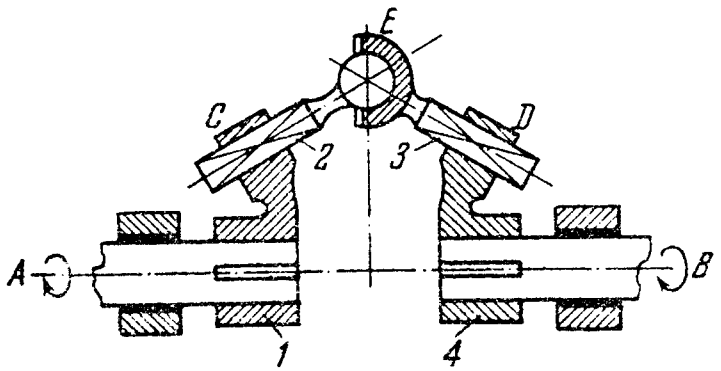
LG 4L




Driving pulley *1* and driven lever *3* rotate about fixed axis *A*. Pin *a* of pulley *1* enters slot *b* of double-arm lever *2* which has collar *k* encircling fixed round eccentric *c*. Pin *d*, on the other arm of lever *2*, enters slot *e* of driven lever *3*. When pulley *1* rotates at constant angular velocity, driven lever *3* rotates at variable angular velocity.

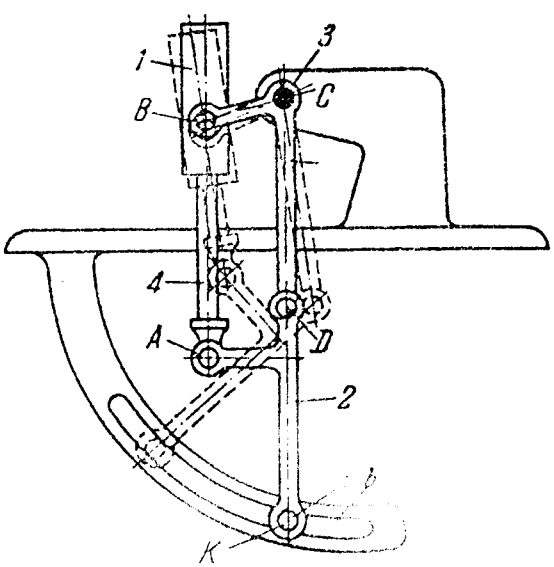
## 3. GENERAL-PURPOSE FIVE-LINK MECHANISMS (994 through 999)

| 994 | FIVE-BAR LINK-GEAR SPATIAL MECHANISM | LG 5L |
|---|---|---|



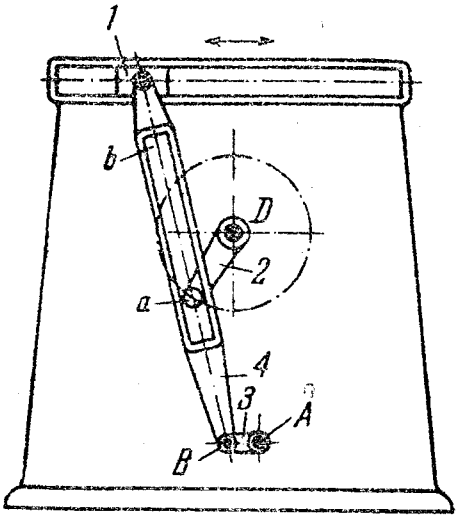

The lengths of links *1* and *2* are equal, respectively, to those of links *4* and *3*. Link *1*, rotating about fixed axis *A*, is connected by sliding pair *C* to link *2*. Link *3* is connected by spherical pair *E* to link *2* and by sliding pair *D* to link *4* which rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

| 995 | FIVE-BAR LINK-GEAR FOLDING-BRACE MECHANISM | LG 5L |
|---|---|---|



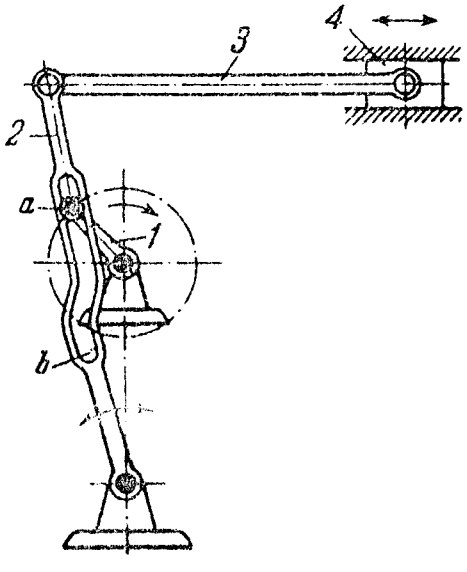

Bent lever *3* turns about fixed axis *C*. Cylinder *1* is connected by turning pair *B* to lever *3*. Rod *4* of the piston sliding in the cylinder is connected by turning pair *A* to link *2*. Link *2*, connected by turning pair *D* to lever *3*, has pin *a* which slides along circular slot *b*. When piston *4* moves into cylinder *1*, the distance between axes *A* and *B* is reduced, and links *2* and *3* take the positions shown by dashed lines. In the working position of the brace, points *C*, *D* and *K* are on a straight line.

| | | |
|---|---|---|
| 996 | FIVE-BAR LINK-GEAR MECHANISM WITH A SUSPENSION LINK | LG 5L |



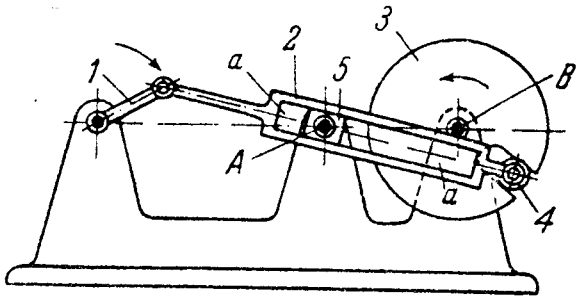

Crank *2*, rotating about fixed axis *D*, has pin *a* which slides in straight slot *b* of slotted link *4*. Link *4* is connected by turning pair *B* to link *3* which turns about fixed axis *A*. By changing the position of axis *A* on the upright, various kinds of motion of slider *1* can be obtained.

| | | |
|---|---|---|
| 997 | FIVE-BAR CURVILINEAR-SLOTTED-LINK MECHANISM | LG 5L |



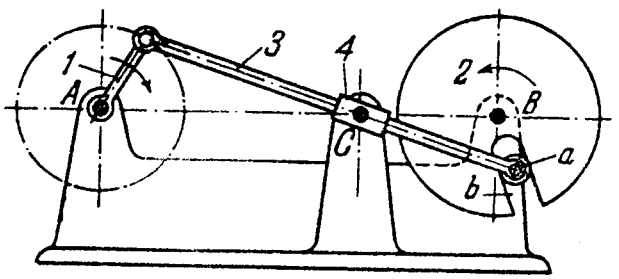

Crank *1* carries roller *a* which slides in curvilinear slot *b* of slotted link *2*. The slot width is equal to the roller diameter. When crank *1* rotates, slotted link *2* and slider *4*, driven by connecting rod *3*, have nonsymmetrical variable motions in the forward and return strokes. By designing slot *b* with various curves, various kinds of motion of slider *2* can be obtained.

| 998 | LINK-GEAR ROTATING-DISK MECHANISM | LG 5L |
|---|---|---|




Link *5*, turning about fixed axis *A*, is designed as a slider along which slotted link *2* with slot *a-a* moves. Slotted link *2* has roller *4* which enters a slot in disk *3*. Disk *3* rotates about fixed axis *B*. When crank *1* rotates at uniform velocity, disk *3* rotates with nonuniform velocity.

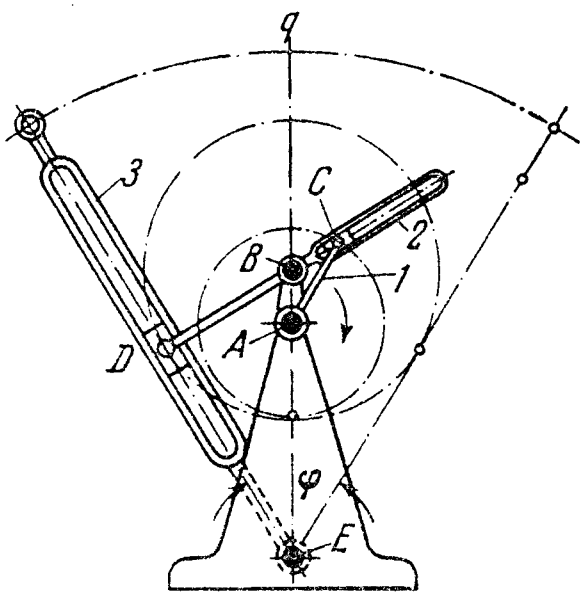
| 999 | SLOTTED-LINK MECHANISM WITH AN ATTACHED DISK | LG 5L |
|---|---|---|




Link *3* moves in slider *4* which turns about fixed axis *C*. Link *3* has pin *a* which enters slot *b* in disk *2*, rotating about fixed axis *B*. When crank *1* rotates at uniform velocity about fixed axis *A*, disk *2* rotates with nonuniform velocity.

# 4. GENERAL-PURPOSE SIX-LINK MECHANISMS (1000 through 1027)

| 1000 | TWO-SLIDER LINK-GEAR MECHANISM | LG 6L |
|---|---|---|




When crank *1* rotates about fixed axis *A*, slotted link *3* oscillates about fixed axis *E* and slotted link *2* rotates about fixed axis *B*. The transmission ratio between links *1* and *3*, having angular velocities $\omega_1$ and $\omega_3$, is

$$i_{13} = \frac{\omega_1}{\omega_3} = -\frac{\sin\alpha}{\sin\gamma\cos(\beta-\alpha)\cos(\beta+\gamma)}$$

where angle $\alpha = \angle CAB$, angle $\beta = \angle CBq$ and angle $\gamma = \angle DEB$ are related by the conditions:

$$\tan\beta = \frac{\overline{AC}\sin\alpha}{\overline{AC}\cos\alpha - \overline{AB}}$$

and

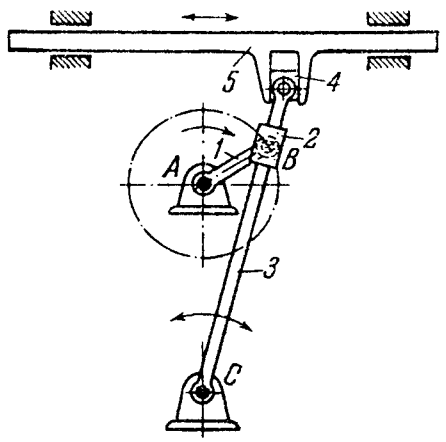
$$\tan\gamma = \frac{\overline{BD}\sin\beta}{\overline{BE} - \overline{BD}\cos\beta}.$$

The full angle of oscillation of slotted link *3* is

$$\varphi = 2\arcsin\frac{\overline{BD}}{\overline{EB}}.$$

## 1001 THREE-SLIDER LINK-GEAR MECHANISM

LG
6L

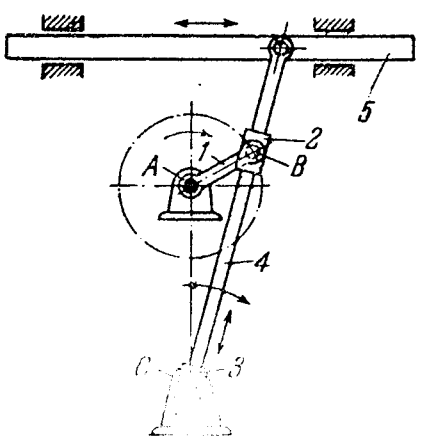



Crank *1*, rotating about fixed axis A, is connected by turning pair *B* to slider *2* which moves along link *3*. Link *3* oscillates about fixed axis *C*. By means of intermediate slider *4*, moving in a guiding slot of slider *5*, link *3* reciprocates slider *5*. Slider *5* travels with different kinds of motion in its forward and return strokes. For rotation of crank *1* at uniform velocity, the time ratio of the forward to the return stroke is

$$k = \frac{\pi}{\arccos \frac{\overline{AB}}{\overline{AC}}} - 1.$$

## 1002 OSCILLATING SLIDING-LINK MECHANISM

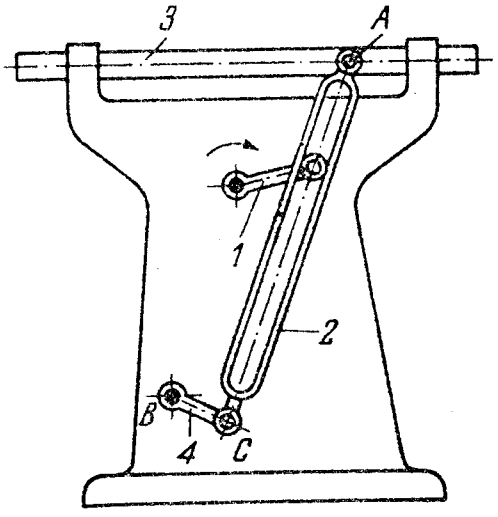
LG
6L




Sliding link *4* is connected by a sliding pair to slider *5* and slides in two guides, *2* and *3*. Guide *3* oscillates about fixed axis *C*. When crank *1* rotates at constant velocity about fixed axis *A*, the time ratio of the forward to the return stroke is

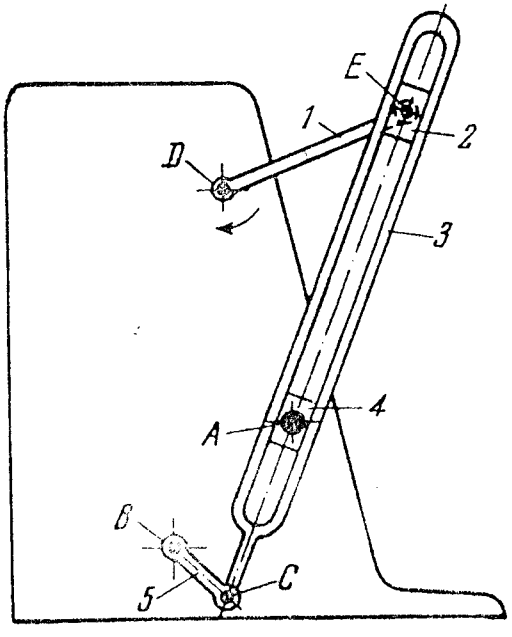
$$k = \frac{\pi}{\arccos \frac{\overline{AB}}{\overline{AC}}} - 1.$$

| 1003 | LINK-GEAR MECHANISM WITH A SUSPENSION LINK | LG 6L |
|---|---|---|



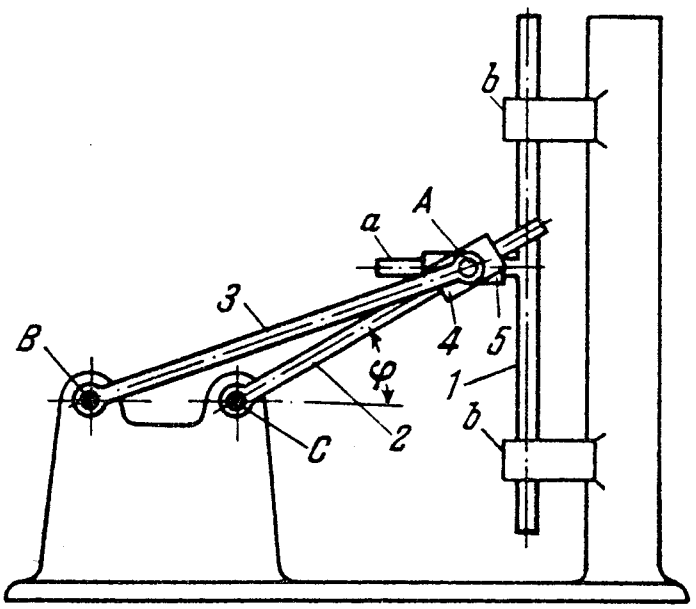

When link *1* rotates, slotted link *2* has a complex motion, oscillating about turning pair *A* and reciprocating together with slider *3*. By changing the length $\overline{BC}$ of link *4* and the position of axis *B* on the fixed upright, various kinds of motion of slider *3* can be obtained.

| 1004 | LINK-GEAR MECHANISM WITH A SUSPENSION LINK | LG 6L |
|---|---|---|



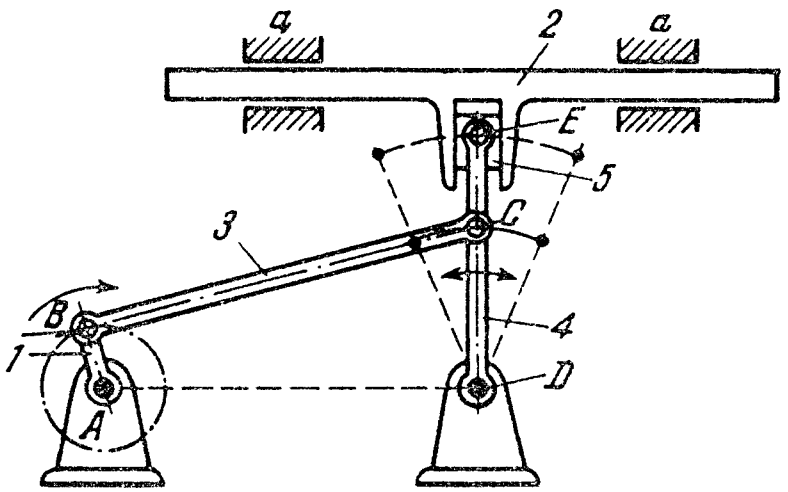

Slider *2*, rotating about fixed axis *D* and connected by turning pair *E* to crank *1*, moves along slotted link *3*. When crank *1* rotates, slotted link *3* moves along slider *4* which turns about fixed axis *A*. Thus link *3* has a complex motion, oscillating about axis *A* and sliding axially. By changing the length $\overline{BC}$ of link *5* and the position of axis *B* on the fixed upright, various kinds of motion of slotted link *3* can be obtained.

| 1005 | LINK-GEAR MECHANISM WITH APPROXIMATELY UNIFORM MOTION OF THE DRIVEN LINK | LG 6L |
|---|---|---|



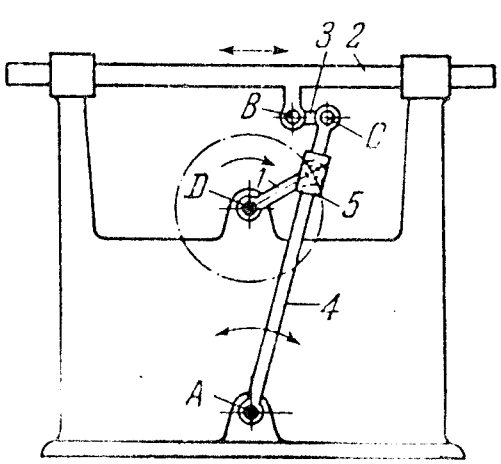

The lengths of the links comply with the condition: $\overline{BC} = 0.34\overline{BA}$. Crank *3*, turning about fixed axis *B*, is connected by turning pair *A* to slider *4* which slides along axis *CA*. Slider *4* is connected by turning pair *A* to slider *5* which moves along extension *a* of link *1*. Link *1* slides in fixed guides *b* whose axis is perpendicular to a line passing through axes *B* and *C*. Extension *a* makes an angle of 90° with the axis of guides *b*. When link *2* oscillates at uniform velocity through angles φ on both sides of line *BC*, link *1* reciprocates with approximately uniform velocity.

| 1006 | TWO-SLIDER LINK-GEAR MECHANISM | LG 6L |
|---|---|---|

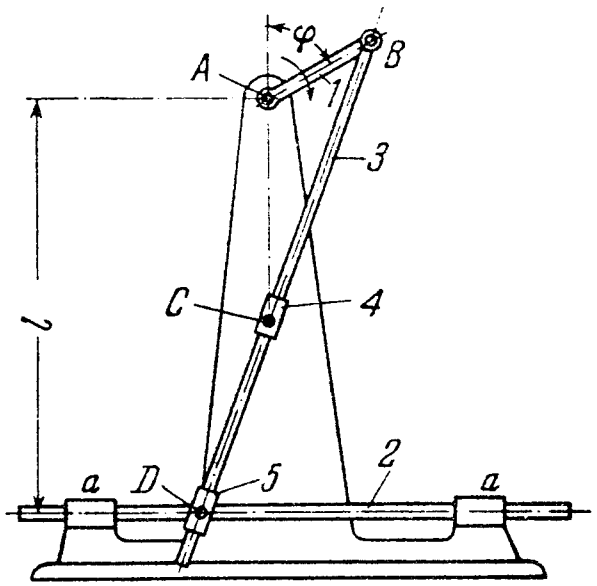



Rocker arm *4* of four-bar linkage *ABCD*, driven by connecting rod *3*, is connected by turning pair *E* to slider *5*. Slider *5* moves in the guiding slot of link *2* which reciprocates in fixed guides *a*. When crank *1* rotates, slider *2* has different velocities in its forward and return strokes.

| 1007 | TWO-SLIDER LINK-GEAR MECHANISM | LG 6L |
|---|---|---|

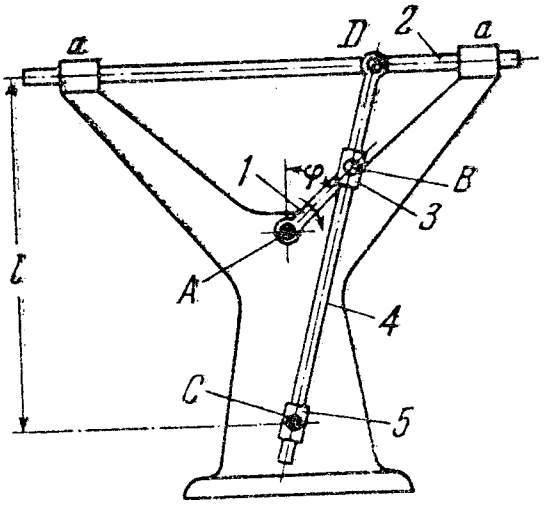



Link *4*, oscillating about fixed axis *A*, is connected by a sliding pair to slider *5* which is driven by crank *1*. Crank *1* rotates about fixed axis *D*. Link *3* is connected by turning pairs *B* and *C* to slide *2* and link *4*. When crank *1* rotates, slide 2 has different kinds of motion in the forward and return strokes. The kind of motion of slide can be varied by changing the length $\overline{BC}$ of link 3.



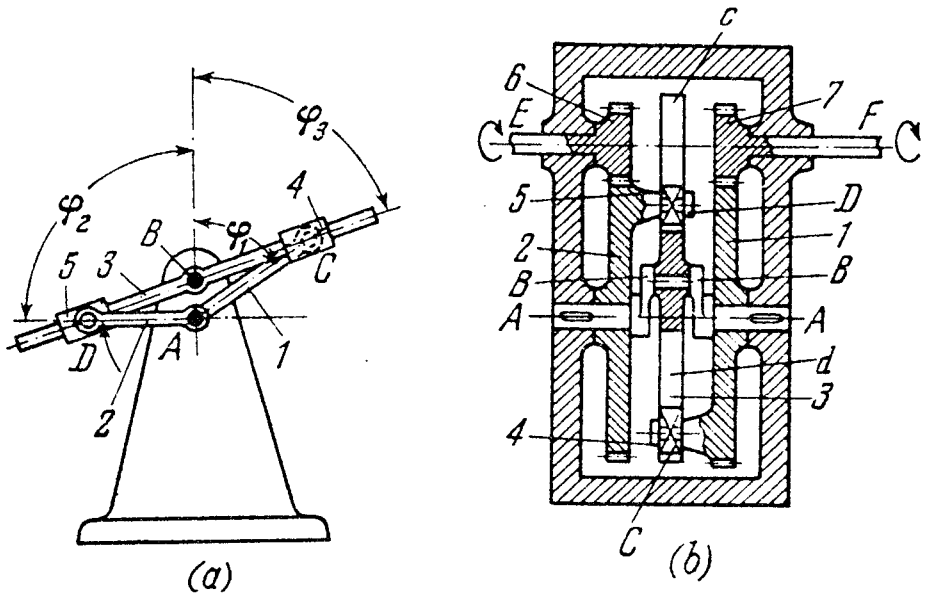

The lengths of the links comply with the conditions: $\overline{AC} = 1.83\overline{AB}$ and $l = 3.57\overline{AB}$. Crank *1*, rotating about fixed axis *A*, is connected by turning pair *B* to link *3* which moves in slider *4*. Slider *4* turns about fixed axis *C*. Link *3* is connected by a sliding pair to slider *5* which, in turn, is connected by turning pair *D* to link *2* sliding in fixed guides *a-a*. When crank *1* oscillates at uniform velocity through angles φ on both sides of vertical line *AC*, link *2* reciprocates with approximately uniform velocity.

| 1009 | LINK-GEAR MECHANISM WITH APPROXIMATELY UNIFORM MOTION OF THE DRIVEN LINK | LG 6L |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AC} = 1.86\,\overline{AB}$ and $l = 3.57\,\overline{AB}$. Crank *1*, rotating about fixed axis *A*, is connected by turning pair *B* to slider *3* which moves along the axis of link *4*. Link *4* is connected by a sliding pair to slider *5* which oscillates about fixed axis *C*. Link *2*, connected by turning pair *D* to link *4*, slides in fixed guides *a-a*. When crank *1* oscillates at uniform velocity through angles φ on both sides of vertical line *AC*, link *2* reciprocates with approximately uniform velocity.

| 1010 | LINK-GEAR MECHANISM WITH TWO ROTATING SLOTTED LINKS | LG 6L |
|---|---|---|

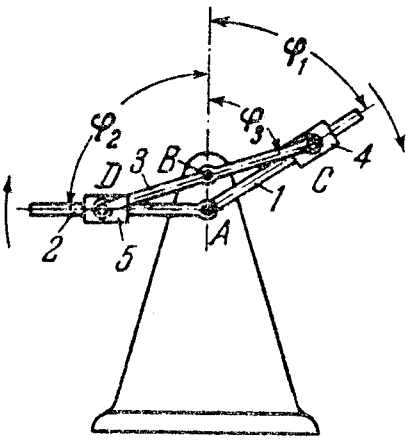



A kinematic diagram of the mechanism is shown in Fig. *a* and a design version of a speed gearbox based on this mechanism is shown in Fig. *b*. Links *1* and *2* rotate independently of each other about fixed axis *A*. Link *3*, rotating about fixed axis *B*, is designed as a slotted link with two slots, *c* and *d*. Link *3* is connected by sliding pairs *C* and *D* to sliders *4* and *5* which, in turn, are connected by turning pairs to cranks *1* and *2*. Cranks *2* and *1* are designed as gears meshing with pinions *6* and *7* which are rigidly mounted on shafts *E* and *F*. These shafts rotate in fixed bearings of the speed gearbox. Angles of rotation $\varphi_1$, $\varphi_2$ and $\varphi_3$ of links *1*, *2* and *3* are related by the conditions:

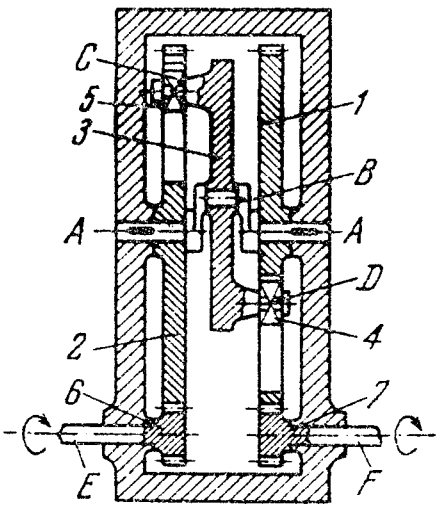
$$\varphi_1 = \arctan \frac{\overline{BC} \sin \varphi_3}{\overline{AB} + \overline{BC} \cos \varphi_3}$$

$$\varphi_2 = \arctan \frac{\overline{BD} \sin \varphi_3}{\overline{BD} - \overline{AD} \cos \varphi_3} .$$

| 1011 | LINK-GEAR MECHANISM WITH TWO ROTATING SLOTTED LINKS | LG 6L |
|---|---|---|




(a)



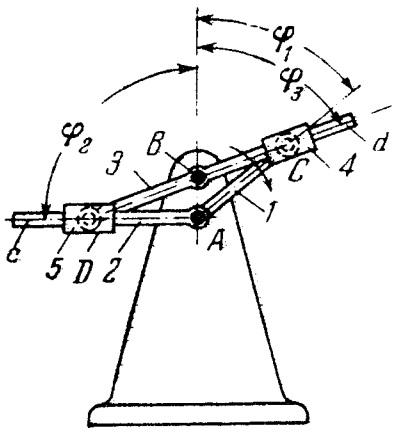

(b)

A kinematic diagram of the mechanism is shown in Fig. *a* and a design version of a speed gearbox based on this mechanism is shown in Fig. *b*. Links *1* and *2* rotate independently of each other about fixed axis *A*. Link *3*, rotating about fixed axis *B*, is designed as a two-arm lever connected by turning pairs *C* and *D* to sliders *5* and *4* which slide in the slots of links *2* and *1*. Links *2* and *1* are designed as gears meshing with pinions *6* and *7* which are rigidly mounted on shafts *E* and *F*. These shafts rotate in fixed bearings of the speed gearbox. Angles of rotation $\varphi_1$, $\varphi_2$ and $\varphi_3$ of links *1*, *2* and *3* are related by the conditions:

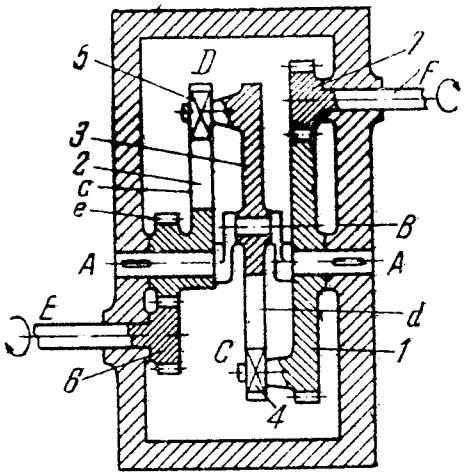
$$\varphi_1 = \arctan \frac{\overline{AC} \sin \varphi_1}{\overline{AC} \cos \varphi_1 - \overline{AB}}$$

$$\varphi_2 = \arctan \frac{\overline{BD} \sin \varphi_3}{\overline{AB} - \overline{BD} \cos \varphi_3} .$$

| 1012 | LINK-GEAR MECHANISM WITH TWO ROTATING SLOTTED LINKS | LG 6L |
|---|---|---|




(a)




(b)

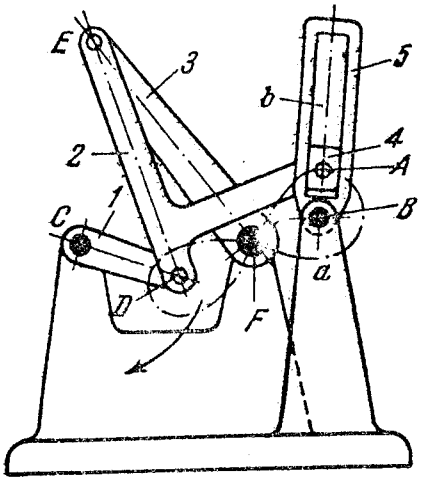
A kinematic diagram of the mechanism is shown in Fig. *a* and a design version of a speed gearbox based on this mechanism is shown in Fig. *b*. Links *1* and *2* rotate independently of each other about fixed axis *A*. Link *3*, rotating about fixed axis *B*, is designed as a two-arm lever connected by turning pair *D* to slider *5* and by sliding pair *C* to slider *4*. Slider *5* moves along slot *c* of link *2*, and slider *4* moves along slot *d* of link *3*. Link *2* is rigidly attached to gear *e* and link *1* is designed as a gear. Gears *e* and *1* mesh with pinions *6* and *7* which are rigidly mounted on shafts *E* and *F*. These shafts rotate in fixed bearings of the speed gearbox. Angles of rotation $\varphi_1$, $\varphi_2$ and $\varphi_3$ of links *1*, *2* and *3* are related by the conditions:

$$\varphi_3 = \arctan \frac{\overline{AC} \sin \varphi_1}{\overline{AC} \cos \varphi_1 - \overline{AB}} =$$

$$= \arctan \frac{\overline{AD} \sin \varphi_2}{\overline{AB} - \overline{AD} \cos \varphi_2} .$$

## 1013 SIX-BAR ROTATING SLOTTED-LINK MECHANISM

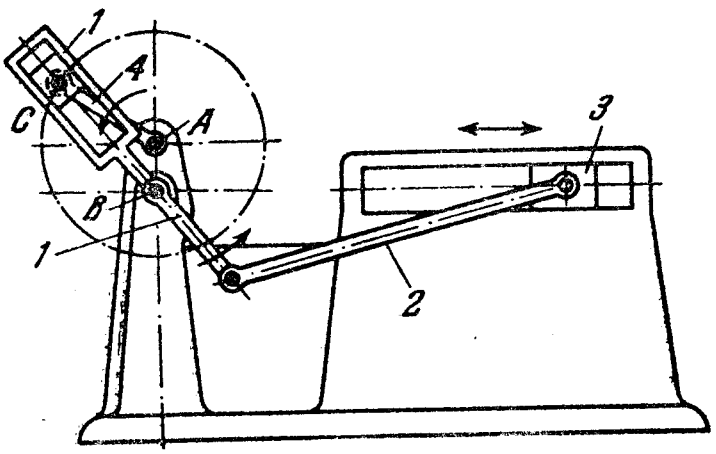
LG 6L




Point *A* of connecting rod *2* in the four-bar linkage *CDEF* describes connecting-rod curve *a* which is self-intersecting at point *F*. Slider *4*, moving along slot *b-b* of slotted link *5*, is connected by turning pair *A* to link *2*. Slotted link *5* rotates about fixed axis *B*. In one revolution of crank *1*, link *5* makes one complete revolution about axis *B*. As point *A* of connecting rod *2* travels along its path, slotted link *5* first rotates clockwise, then turns through a certain angle in the reverse direction and finally continues in the initial direction.

## 1014 LINK-GEAR MECHANISM WITH ATTACHED CONNECTING ROD AND SLIDER

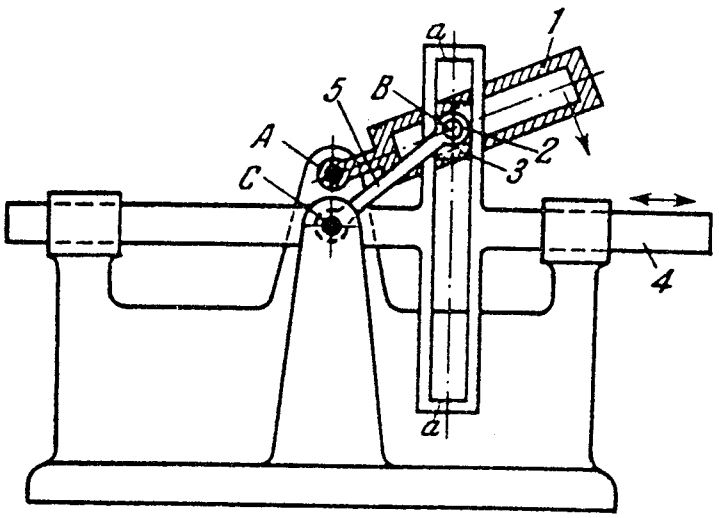
LG 6L




Link *1* of four-bar slotted link mechanism *ABC* drives connecting rod *2* and slider *3* which has different forward and return stroke times. For rotation of crank *4* at uniform velocity, the time ratio of the forward to the return stroke is

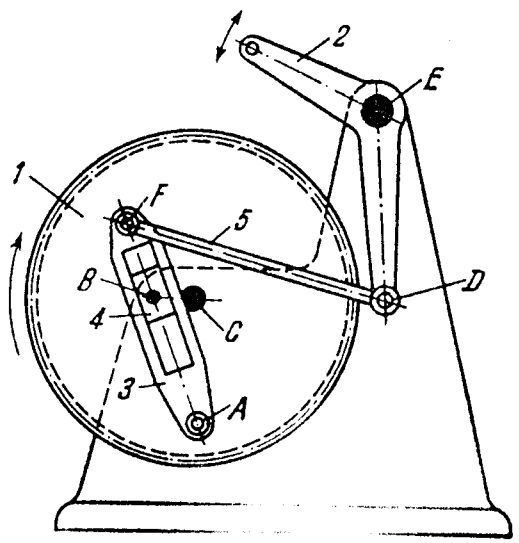
$$k = \frac{\pi}{\arccos \frac{\overline{AB}}{\overline{AC}}} - 1.$$

| 1015 | SIX-BAR RECIPROCATING-SLOTTED-LINK MECHANISM (MODIFIED SCOTCH YOKE) | LG 6L |
|---|---|---|



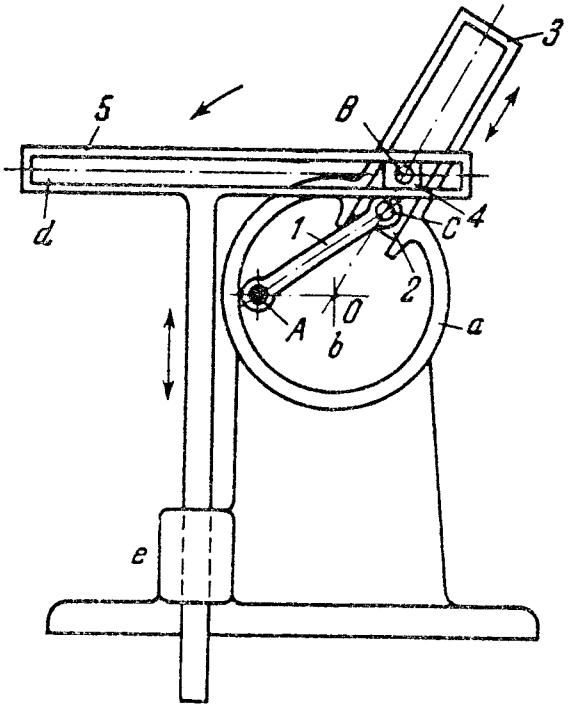

Roller *2*, sliding in slotted link *1*, is connected by turning pair *B* to slider *3* which moves along slot *a-a* of link *4*. Slotted link *1* makes complete revolutions about fixed axis *A*. When link *1* rotates at uniform velocity, link *5* rotates with nonuniform velocity about fixed axis *C*, and link *4* has different forward and return stroke times.

| 1016 | SIX-BAR LINK-GEAR OSCILLATING-LEVER MECHANISM | LG 6L |
|---|---|---|




Link *1*, designed as a gear, rotates about fixed axis *C*. Slotted link *3* is connected by turning pair *A* to gear *1*. Slider *4* rotates about fixed axis *B*. Link *5* is connected by turning pairs *F* and *D* to slotted link *3* and lever *2* which oscillates about fixed axis *E*. When link *1* rotates, lever *2* oscillates. Point *F* describes a connecting-rod curve. The mechanism is driven by gearing which is not shown.

| 1017 | ECCENTRIC SLOTTED-LINK MECHANISM | LG 6L |
|---|---|---|



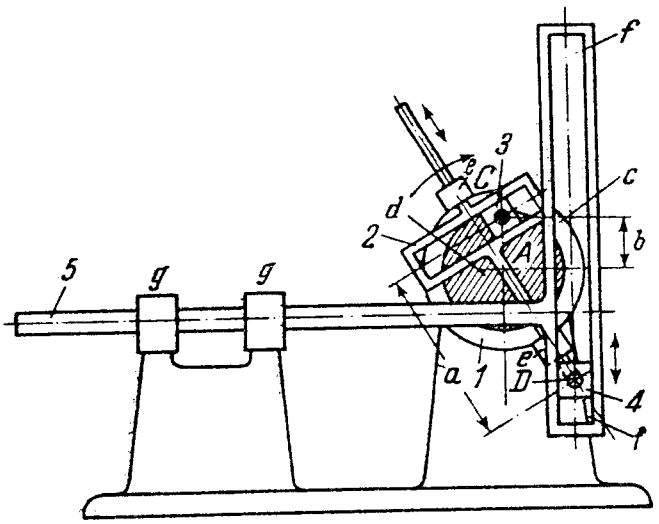

Slotted link *3* has collar *a* encircling fixed eccentric *b* whose centre is at point *O*. Crank *1* is connected by turning pair *C* to slider *2*. Slider *2* is connected by turning pair *B* to slider *4* which moves along slot *d* of link *5*. Link *5* reciprocates in fixed guide *e*. When crank *1* rotates, slotted link *3* turns about eccentric *b*, transmitting motion to link *5* through slider *4*. A full stroke of link *5* equals

$$s = 2\left(\overline{AC} + \frac{\overline{AC} \times \overline{BC}}{\sqrt{\overline{AC}^2 + \overline{AO}^2}}\right).$$

The time ratio of the forward to the return stroke of link *5* is

$$k = 1.$$

| 1018 | ECCENTRIC SLOTTED-LINK MECHANISM | LG 6L |
|---|---|---|




Link *1* is designed as collar *c* encircling fixed disk *d*. Slider *3* rotates about fixed axis *C*. Link *2* reciprocates in guides *e*. Link *2* is connected by turning pair *D* to slider *4* which moves along slot *f* of link *5*. Link *5* reciprocates in fixed guides *g-g*. The displacement of link *5* from its extreme left or right position is

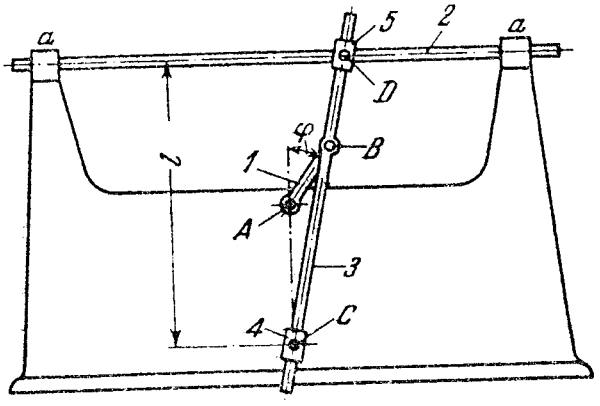
$$s = a\,(1 - \sin\alpha) + \frac{b}{2}\sin 2\alpha$$

where $\alpha$ is the angle of rotation of link *2* measured from the vertical axis. The ratio of the maximum velocities of the forward to the return stroke is

$$k = \frac{a-b}{a+b}\,.$$

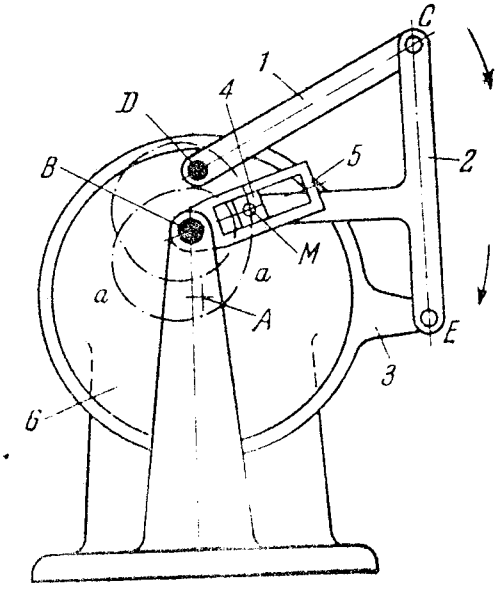
Point *D* of the mechanism describes a conchoid of a circle.

| 1019 | LINK-GEAR MECHANISM WITH APPROXIMATELY UNIFORM MOTION OF THE DRIVEN LINK | LG 6L |
|---|---|---|



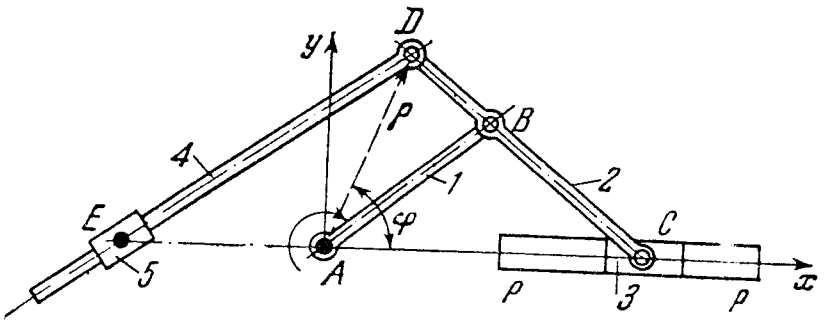

The lengths of the links comply with the conditions: $\overline{AC} = 1.86\overline{AB}$ and $l = 3.47\overline{AB}$. Crank *1*, rotating about fixed axis *A*, is connected by turning pair *B* to link *3*. Link *3* moves in slider *4*, turning about fixed axis *C*, and in slider *5* which is connected by turning pair *D* to link *2*. Link *2* reciprocates in fixed guides *a*. When crank *1* oscillates at uniform velocity through angles φ on both sides of vertical line *AC*, link *2* reciprocates with approximately uniform velocity.

| 1020 | SIX-BAR ROTATING-SLOTTED-LINK MECHANISM | LG 6L |
|---|---|---|




Point *M* of connecting rod *2* in the four-bar drag-link linkage *AECD* describes connecting-rod curve *a-a* with one point of self-intersection. Slider *4* is connected by turning pair *M* to connecting rod *2* and slides in slotted link *5* which rotates about fixed axis *B*. Crank *3* is designed as a collar encircling fixed disk *6* which has its centre at point *A*. Owing to the shape of the connecting-rod curve *a-a*, slotted link *5* makes two complete revolutions about axis *B* to each revolution of cranks *1* and *3*.

| 1021 | SIX-BAR MECHANISM WITH AN ELLIPTIC CRANK OF VARIABLE LENGTH | LG 6L |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AB} = \overline{BC}$. Link *1*, rotating about fixed axis *A*, is connected by turning pair *B* to link *2*. Link *2* is connected by turning pairs *D* and *C* to link *4* and slider *3*. Slider *3* moves along fixed guides *p-p*. Link *4* is connected by a sliding pair to slider *5* which turns about fixed axis *E*. Point *D* describes an ellipse with its centre at point *A* and having the equation

$$\frac{x^2}{(m-n)^2} + \frac{y^2}{(m+n)^2} = 1.$$

The variable vector $\boldsymbol{\rho} = \overline{AD}$ can be regarded as the crank of slotted-link mechanism *ADE* with oscillating slider *5* and variable length $\overline{AD}$:

$$\overline{AD} = (m^2 - n^2)\sqrt{\frac{1}{m^2 + n^2 + 2mn\cos 2\varphi}}$$

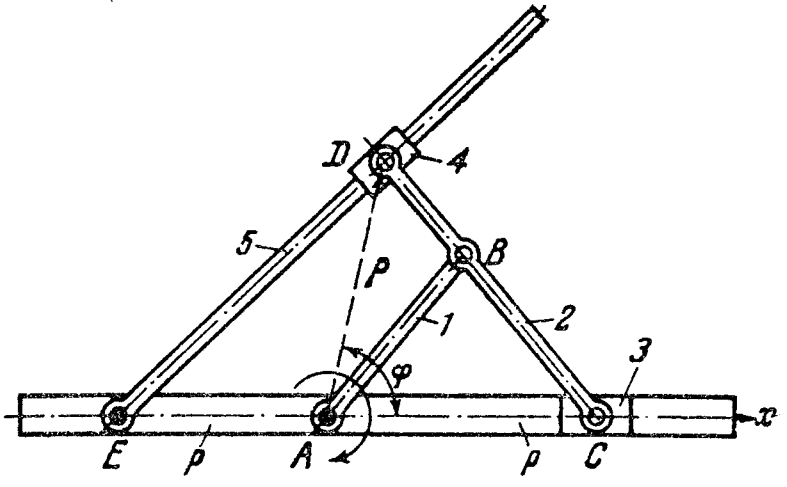
where $\varphi$ = angle between vector $\boldsymbol{\rho}$ and axis $Ax$

$m = \overline{AB}$

$n = \overline{BD}$.

## 1022 SIX-BAR MECHANISM WITH AN ELLIPTIC CRANK OF VARIABLE LENGTH

LG 6L




The lengths of the links comply with the condition: $\overline{AB} = \overline{BC}$. Link *1*, rotating about fixed axis *A*, is connected by turning pair *B* to link *2*. Link *2* is connected by turning pairs *D* and *C* to sliders *4* and *3*. Slider *3* moves along fixed guides *p-p*. Slider *4* is connected by a sliding pair to link *5* which turns about fixed axis *E*. Point *D* describes an ellipse with its centre at point *A* and having the equation

$$\frac{x^2}{(m-n)^2} + \frac{y^2}{(m+n)^2} = 1.$$

The variable vector $\boldsymbol{\rho} = \overline{AD}$ can be regarded as the crank of slotted-link mechanism *ADE* with crank *AD* of variable length and equal to

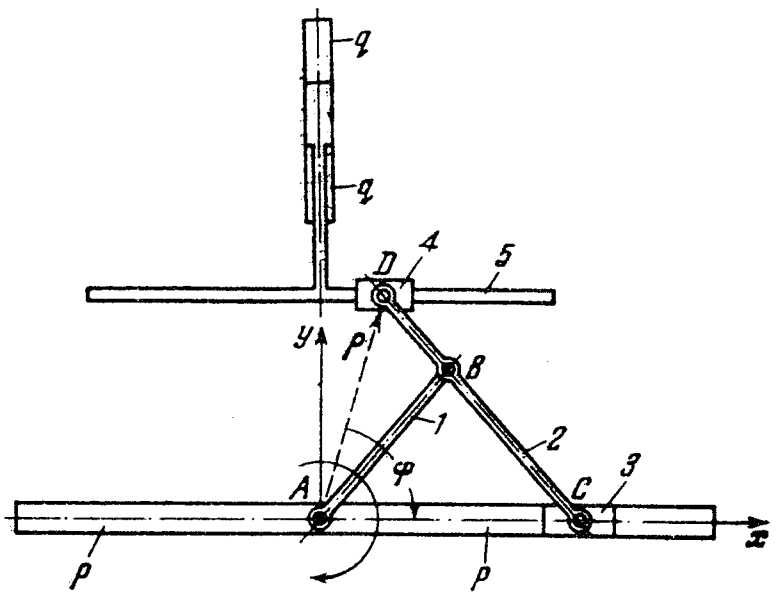
$$\overline{AD} = (m^2 - n^2)^2 \sqrt{\frac{1}{m^2 + n^2 + 2mn\cos 2\varphi}}$$

where $\varphi$ = angle between vector $\boldsymbol{\rho}$ and axis *Ax*

$m = \overline{AB}$

$n = \overline{BD}$.

| 1023 | SIX-BAR MECHANISM WITN AN ELLIPTIC CRANK OF VARIABLE LENGTH | LG 6L |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AB} = \overline{BC}$. Link *1*, rotating about fixed axis *A*, is connected by turning pair *B* to link *2*. Link *2* is connected by turning pairs *D* and *C* to sliders *4* and *3*. Slider *3* moves along fixed guides *p-p*. Slider *4* is connected by a sliding pair to link *5* which slides along fixed guides *q-q*. Point *D* describes an ellipse with its centre at point *A* and having the equation

$$\frac{x^2}{(m-n)^2} + \frac{y^2}{(m+n)^2} = 1.$$

The variable vector $\boldsymbol{\rho} = \overline{AD}$ can be regarded as the crank of slotted-link mechanism *ADC* with crank *AD* of variable length and equal to

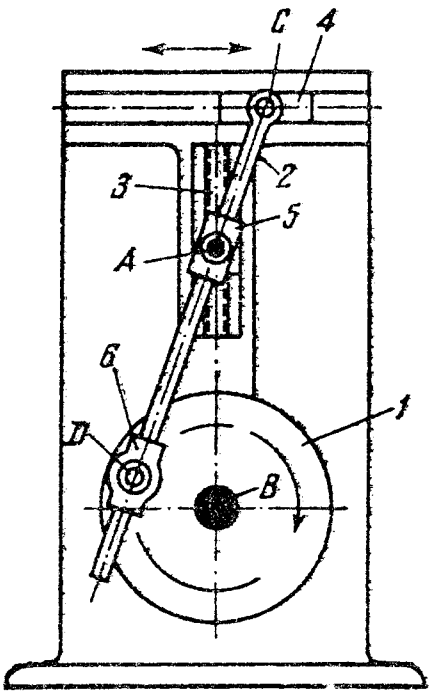
$$\overline{AD} = (m^2 - n^2)\sqrt{\frac{1}{m^2 + n^2 + 2mn\cos 2\varphi}}$$

where $\varphi$ = angle between vector $\boldsymbol{\rho}$ and axis $Ax$

$m = \overline{AB}$

$n = \overline{BD}$.

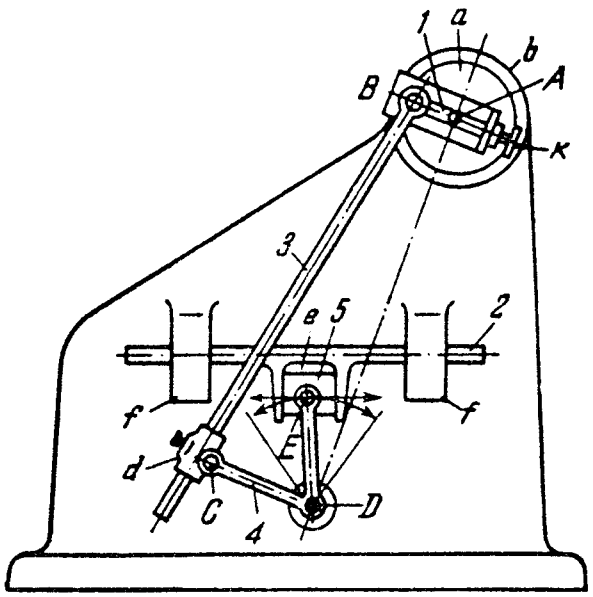
| 1024 | LINK-GEAR MECHANISM WITH A VARIABLE SLIDER STROKE | LG 6L |
|---|---|---|




Sliding link *2*, connected by turning pair *C* to slider *4*, moves in sliders *5* and *6* which turn about axes *A* and *B*. Adjustment of screw *3* changes the position of axis *A* and this varies the stroke of slider *4*. The full stroke of slider *4* equals

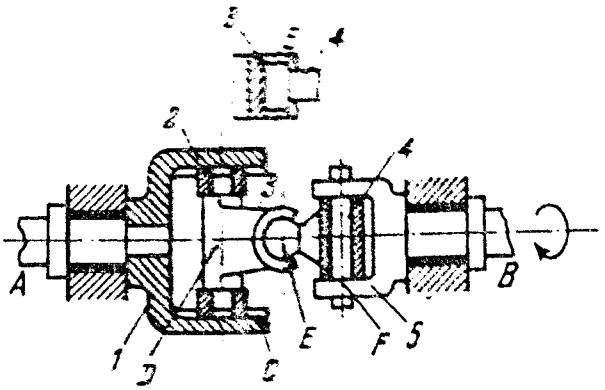
$$s = 2\overline{BD}\,\frac{\overline{AB}}{\overline{AC}}\,.$$

| 1025 | LINK-GEAR MECHANISM WITH AN ADJUSTABLE SLIDER STROKE | LG 6L |
|---|---|---|



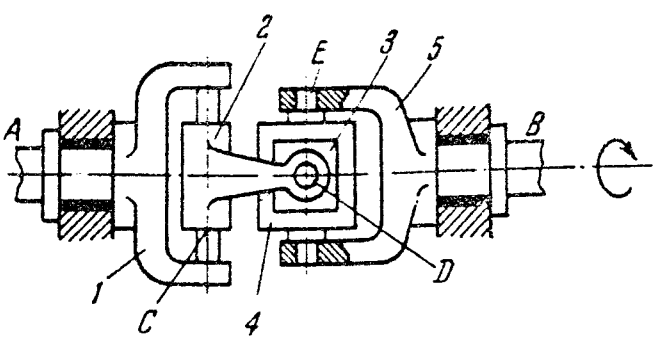

Crank *1* is rigidly secured to disk *a* which rotates in fixed collar *b* having its centre at point *A*. Link *3* is connected by turning pairs *B* and *C* to links *1* and *4*. Link *4*, rotating about fixed axis *D*, is connected by turning pair *E* to slider *5* which moves in fixed guide *e* of slider *2*. Slider *2*, in its turn, moves in fixed guides *f-f*. The length $\overline{AB}$ of the crank can be varied by means of screw device *k*, and the length $\overline{BC}$ of connecting rod *3* can be changed by adjusting and clamping sleeve *d* in various positions along link *3*. When crank *1* rotates slider *2* reciprocates. The stroke of slider *2* is adjusted by changing the lengths of crank *1* and connecting rod *3*.

| 1026 | SIX-BAR LINK-GEAR SPATIAL MECHANISM | LG 6L |
|---|---|---|




Link *1*, rotating about fixed axis *A*, is connected by sliding pair *C* to link *3*. Link *4* is connected by cylindrical turning and sliding pair *E* to link *3* and by turning pair *F* to link *5*. Link *5* rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

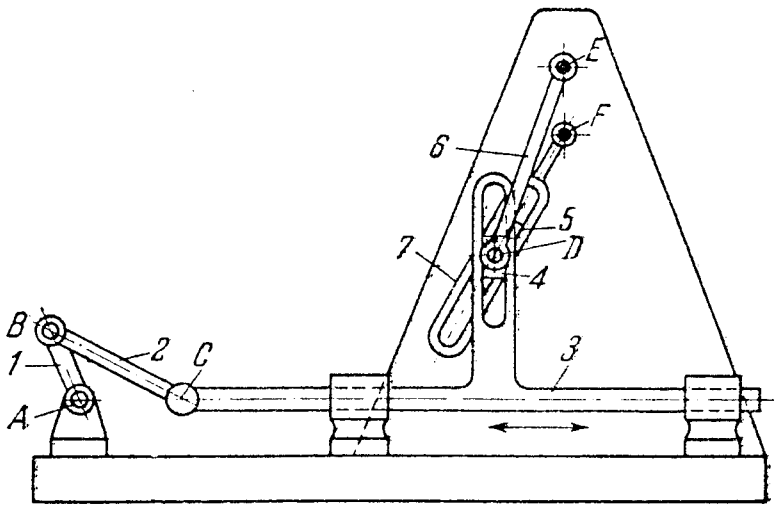
| 1027 | SIX-BAR LINK-GEAR SPATIAL MECHANISM | LG 6L |
|---|---|---|




Link *1*, rotating about fixed axis *A*, is connected by turning and sliding pair *C* to link *2*. Link *2* is connected by turning pair *D* to slider *3* which moves in guides of link *4*. Link *4* is connected by turning pair *E* to link *5* which rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

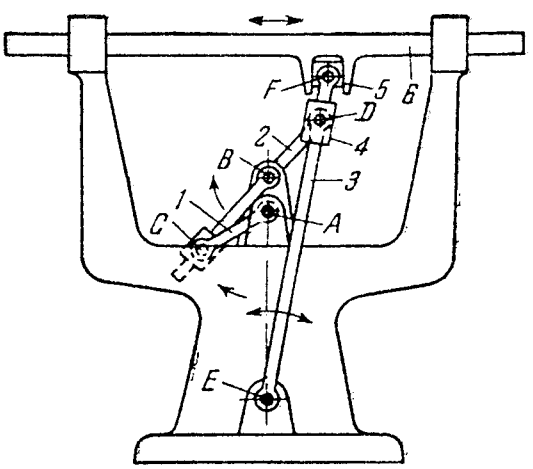
## 5. GENERAL-PURPOSE MULTIPLE-LINK MECHANISMS (1028 through 1042)

| 1028 | THREE-SLIDER LINK-GEAR MECHANISM | LG ML |
|---|---|---|




Slider *4*, mounted on pin *D* of rocker arm *6*, moves in the slot of link *3*. Slider *5* moves in the guiding slot of slotted link *7*. When crank *1* rotates about fixed axis *A*, link *3*, connected to crank *1* by connecting rod *2*, reciprocates. At this rocker arm *6* and slotted link *7* oscillate about fixed axes *E* and *F*.

| 1029 | FOUR-SLIDER LINK-GEAR MECHANISM | LG ML |
|---|---|---|



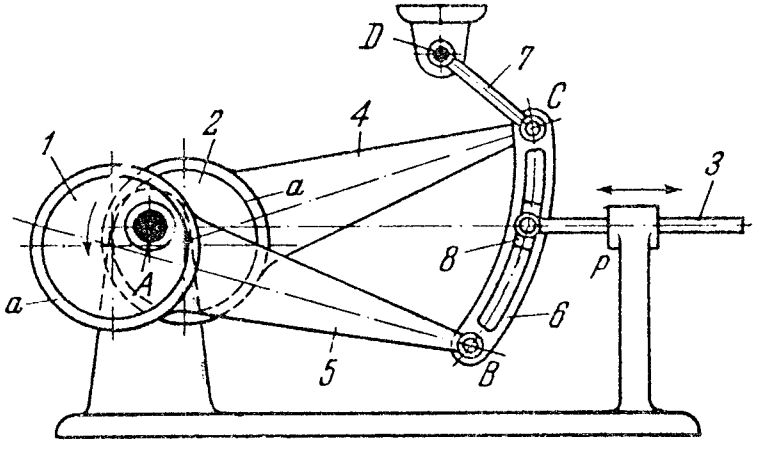

Connected to link *2* of slotted-link mechanism *ABC* with crank *1* is slider *4* which moves along the axis of link *3*. Link *3* is connected by turning pair *F* to slider *5* which moves in a guide of link *6*. If the angles formed by the axes of *AC*, *BC* and *EF* with the direction *BE* are denoted by $\alpha = \angle CAE$, $\beta = \angle CBA$ and $\gamma = \angle DEB$, then these angles are related by the equations

$$\tan\beta = \frac{\overline{AC}\sin\alpha}{\overline{AB} + \overline{AC}\cos\alpha}$$

and

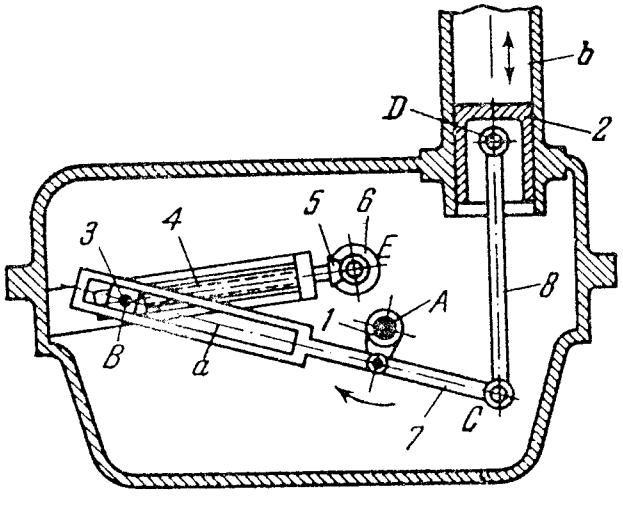
$$\tan\gamma = \frac{\overline{BD}\sin\beta}{\overline{EB} + \overline{BD}\cos\beta}.$$

| 1030 | DOUBLE-ECCENTRIC LINK-GEAR MECHANISM | LG ML |
|---|---|---|



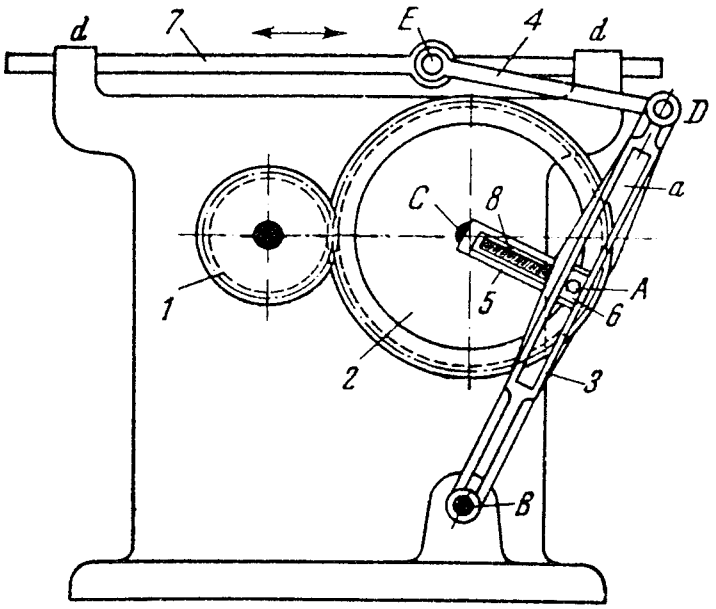

Eccentrics *1* and *2* are rigidly secured together and rotate about fixed axis *A*. Links *4* and *5* have collars *a* which encircle eccentrics *1* and *2*. Circular slotted link *6* is connected by turning pairs *C* and *B* to links *4* and *5*. Circular slider *8*, moving along the slot of link *6*, is connected by a turning pair to rod *3* which slides in fixed guide *p*. Link *7*, rotating about fixed axis *D*, is connected by turning pair *C* to slotted link *6*. When eccentrics *1* and *2* rotate, rod *3* reciprocates.

| 1031 | LINK-GEAR MECHANISM WITH AN ADJUSTABLE SLIDER STROKE | LG ML |
|---|---|---|

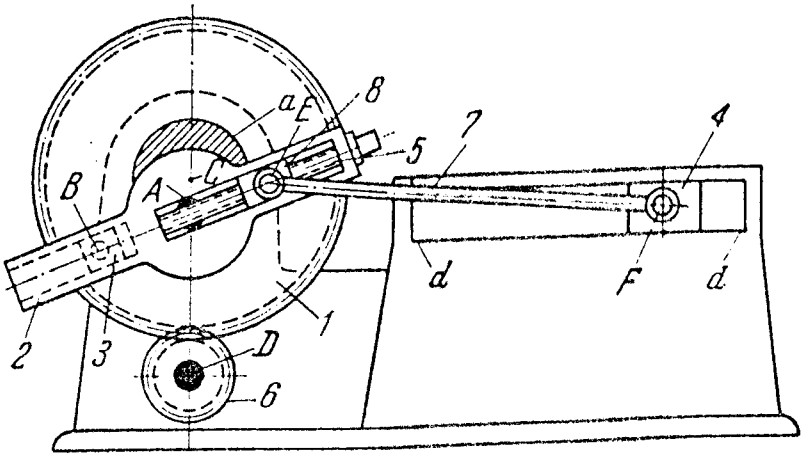


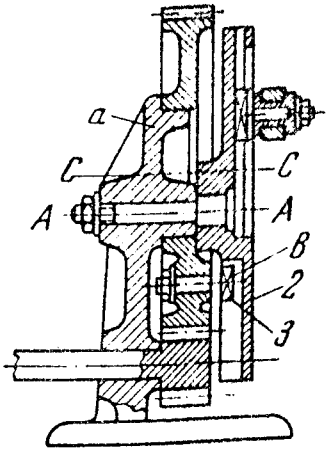

Crank *1* rotates about fixed axis *A*. Slot *a* of slotted link *7* [illegible] along slider *3* which turns about fixed axis *B*. Connecting rod *8* is connected by turning pairs *C* and *D* to slotted link *7* and piston *2* which slides in fixed cylinder *b*. When crank *1* rotates, piston *2* reciprocates. The piston stroke is adjusted by screw device *4* which varies the distance $\overline{EB}$. The screw is turned by bevel gears *5* and *6*.

| 1032 | LINK-GEAR MECHANISM WITH AN ADJUSTABLE SLIDER STROKE | LG ML |
|---|---|---|



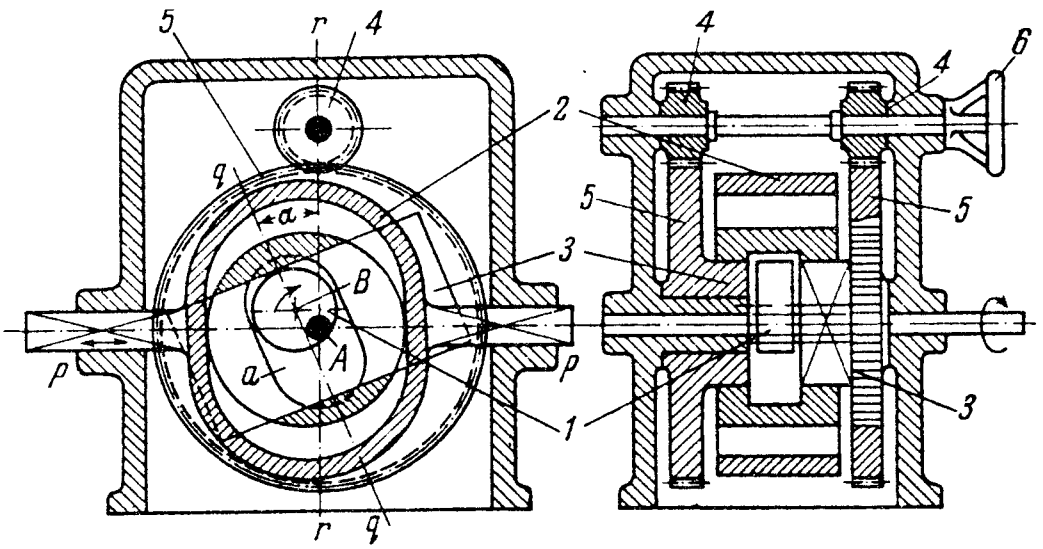

Crank *5*, rotating about fixed axis *C*, is rigidly secured to gear *2* which is driven by pinion *1*. Crank *5* is connected by turning pair *A* to slider *6* which moves along slot *a* of slotted link *3*. Link *3* turns about fixed axis *B*. Link *4* is connected by turning pair *D* to slotted link *3* and by turning pair *E* to slider *7* which moves in fixed guides *d-d*. Length $\overline{AC}$ of crank *5* can be adjusted by screw device *8*, thereby varying the stroke of slider *7*. Slider *7* has different velocities in its forward and return strokes.




Slotted link *2*, rotating about fixed axis *A*, is connected by a sliding pair to slider *3* which rotates about the axis of pin *B* of link *1*. Link *1* is designed as a gear rotating freely on fixed ring *a*. Gear *1* is driven by pinion *6* which rotates about fixed axis *D*. Connecting rod *7* is connected by turning pairs *E* and *F* to slotted link *2* and slider *4*. Slotted link *2* has a slot along which slider *8* can be adjusted by means of screw device *5*. This changes the length *AE* of link *2* and thereby varies the stroke of slider *4* in fixed guides *d-d*. When pinion *6* rotates, slider *4* reciprocates.

| 1034 | ECCENTRIC AND SLOTTED-LINK MECHANISM WITH DRIVEN LINK STROKE ADJUSTMENT | LG ML |
|---|---|---|




Eccentric *1* rotates about fixed axis *A*. Link *2* slides in fixed guides *p-p*. Link *2* has prismatic guides *3* with slot *a*. Guides *3* are rigidly secured to gears *5* which mesh with pinions *4*. Pinions *4* are turned by handwheel *6*. The displacement of link *2* is

$$s_2 = \overline{AB}\,(\sin\varphi - \cos\varphi \tan\alpha)$$

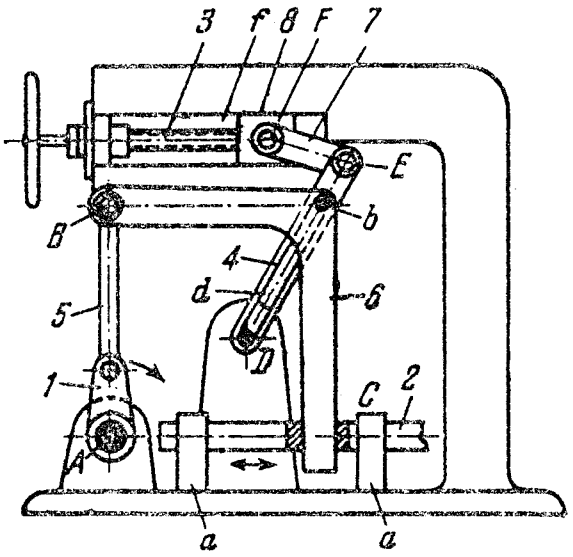
where $\overline{AB}$ = distance from axis of rotation *A* to centre *B* of eccentric *1*

$\varphi$ = angle between line *AB* and axis *r-r*

$\alpha$ = angle between axis *q-q* of slot *a* and axis *r-r*.

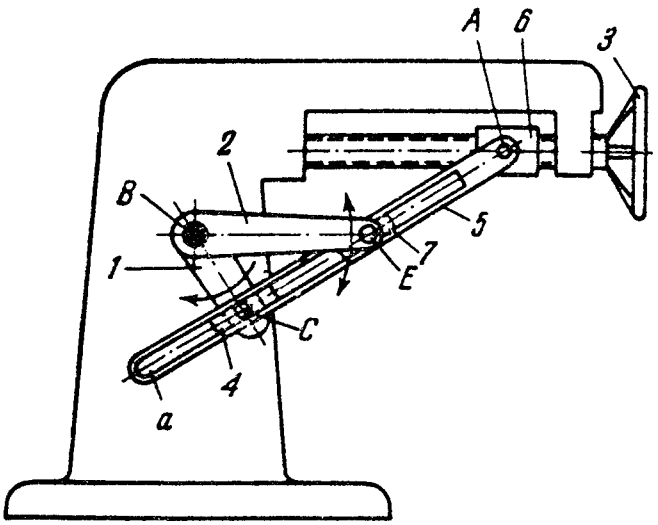
When eccentric *1* rotates, slotted link *2* reciprocates. The stroke $s_2$ of slotted link *2* is adjusted by changing angle of inclination $\alpha$ of prismatic guides *3*, attached to gears *5*, by means of pinions *4*.

| 1035 | LINK-GEAR MECHANISM WITH DRIVEN LINK STROKE ADJUSTMENT | LG ML |
|---|---|---|



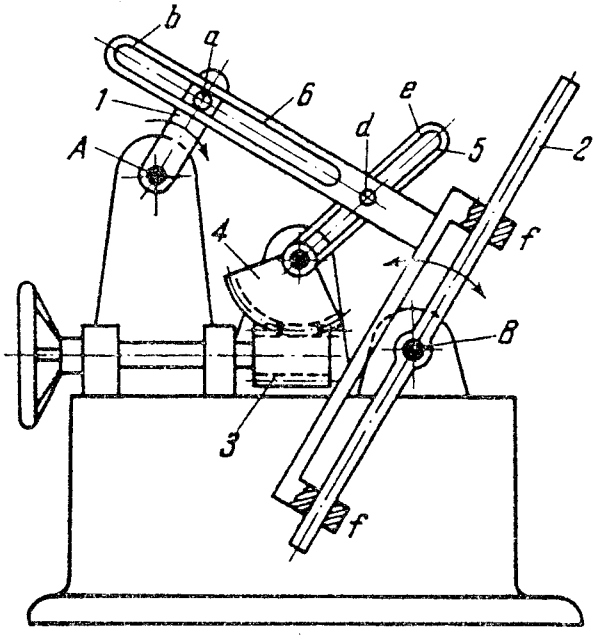

Crank *1*, rotating about fixed axis *A*, drives link *6* through intermediate link *5*. Link *6* is connected by turning pair *B* to link *5* and by sliding pair *C* to link *2* which slides in fixed guides *a-a*. Pin *b* of link *6* slides in slot *d* of link *4* which turns about fixed axis *D*. Link *7* is connected by turning pairs *E* and *F* to link *4* and slider *8* which moves in fixed guide slot *f*. Slider *8* is connected by a screw pair to link *3*. When crank *1* rotates, link *2* reciprocates. The stroke of link *2* can be adjusted by changing the position of link *4*. This is done by turning screw *3*. The stroke can be changed in operation.

| 1036 | LINK-GEAR MECHANISM WITH DRIVEN LINK ANGLE OF OSCILLATION ADJUSTMENT | LG, ML |
|---|---|---|



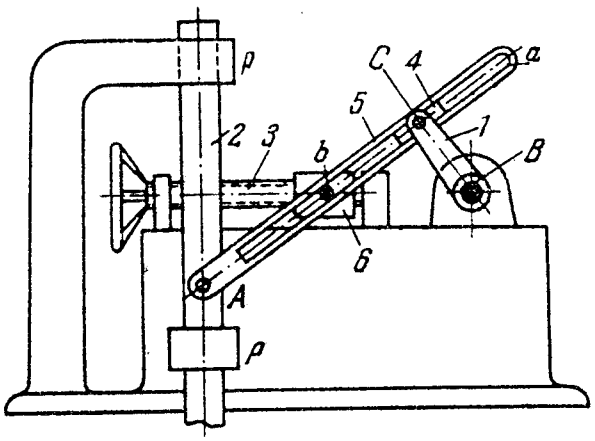

Crank *1*, rotating about fixed axis *B*, is connected by turning pair *C* to slider *4* which moves along slot *a* of slotted link *5*. Link *5* turns about axis *A* which belongs to stationary slider *6*. Link *2* turns about fixed axis *B* and is connected by turning pair *E* to slider *7* which moves along slot *a*. When crank *1* rotates, link *2* oscillates. The angle of oscillation of link *2* can be adjusted by changing the position of pin *A* with screw *3*. Adjustment can be made in operation.

| 1037 | LINK-GEAR MECHANISM WITN DRIVEN LINK ANGLE OF OSCILLATION ADJUSTMENT | LG ML |
|---|---|---|



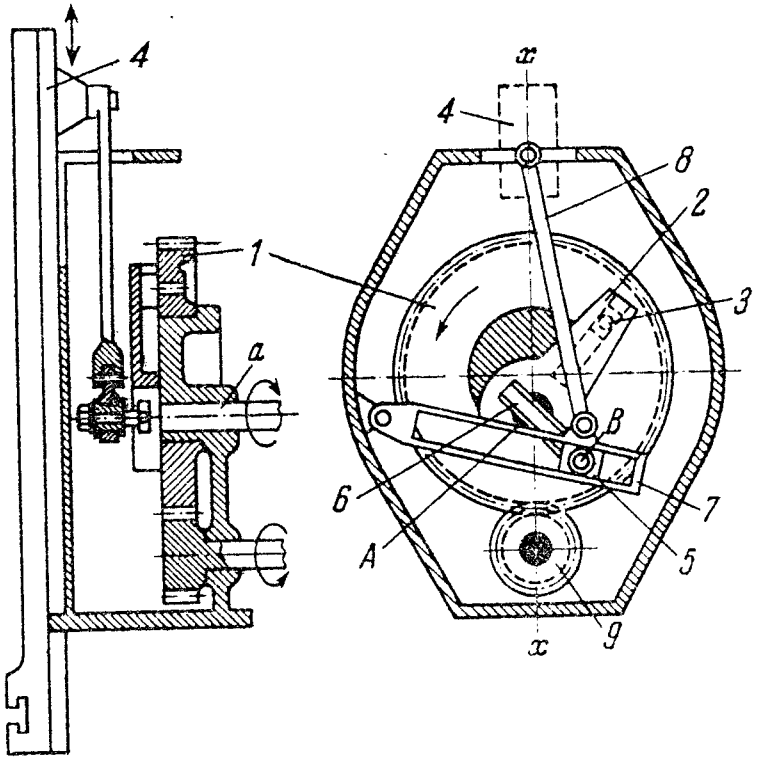

Crank *1*, rotating about fixed axis *A*, has pin *a* sliding in slot *b* of link *6*. Pin *d* of link *6* slides in slot *e* of slotted link *5* which is rigidly secured to worm wheel segment *4*. At the end of link *6* are two lugs *f* which slide along the axis of link *2*. Link *2* turns about fixed axis *B*. When crank *1* rotates, link *2* oscillates. The angle of oscillation of link *2* can be adjusted by turning worm *3* with the handwheel. This turns worm wheel segment *4*, changing the position of slotted link *5*. Adjustment can be made in operation.

| 1038 | LINK-GEAR MECHANISM WITH DRIVEN LINK STROKE ADJUSTMENT | LG ML |
|---|---|---|

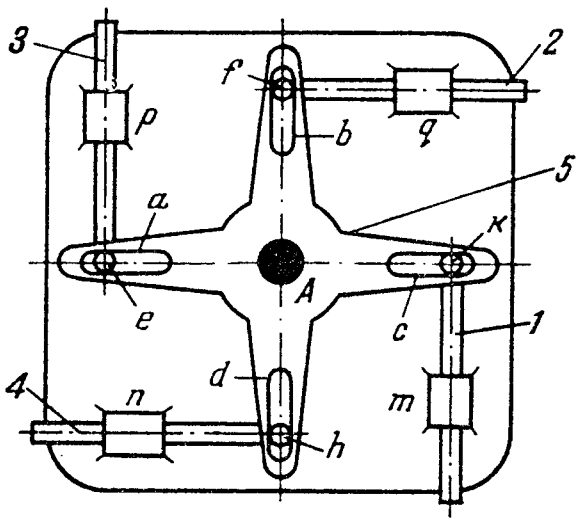



Crank *1*, rotating about fixed axis *B*, is connected by turning pair *C* to slider *4* which moves along slot *a* of slotted link *5*. Link *5* is connected by turning pair *A* to slider *2* which moves in fixed guides *p-p*. Slot *a* of slotted link *5* slides along pin *b* which belongs to slider *6*. When crank *1* rotates, link *2* reciprocates. The stroke of link *2* can be adjusted by turning screw *3* to change the position of slider *6*. Adjustment can be made in operation.

| 1039 | LINK-GEAR MECHANISM WITH DRIVEN LINK STROKE ADJUSMTENT | LG ML |
|---|---|---|

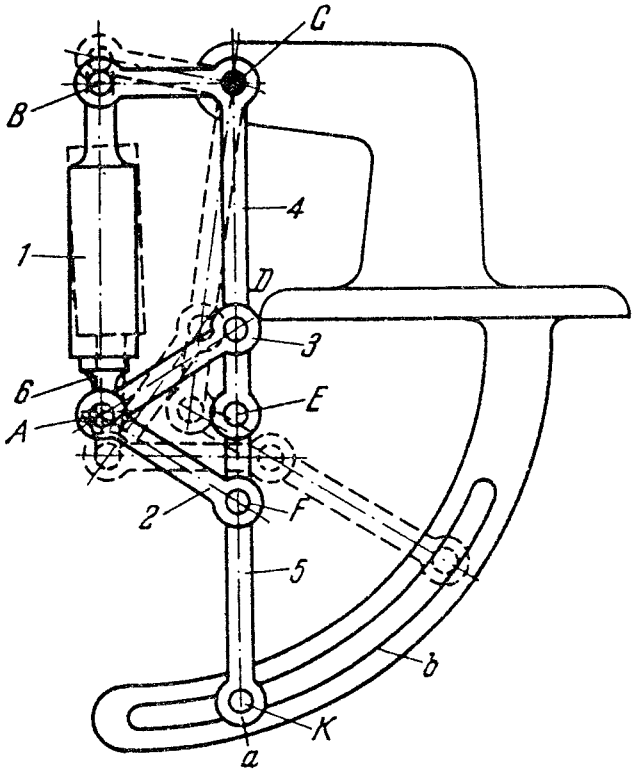



Slider *3* rotates freely on a pin mounted rigidly on gear *1* which is driven by pinion *9*. Slider *3* moves in a groove of slotted link *2* which rotates about fixed axis *A*. Rigidly secured to link *2* is link *6* which is connected by turning pair *B* to slider *5*. Slider *5* moves in slotted link *7* which is connected by a turning pair to connecting rod *8*. Connecting rod *8* drives ram *4*. When gear *1* rotates, ram *4* reciprocates along axis *x-x*. The stroke of ram *4* is adjusted by changing the position of point *B* of slider *5* in the groove of link *6*. The nonuniform rotation of slotted link *2* can be used to drive a second driven link rigidly mounted on shaft *a*.



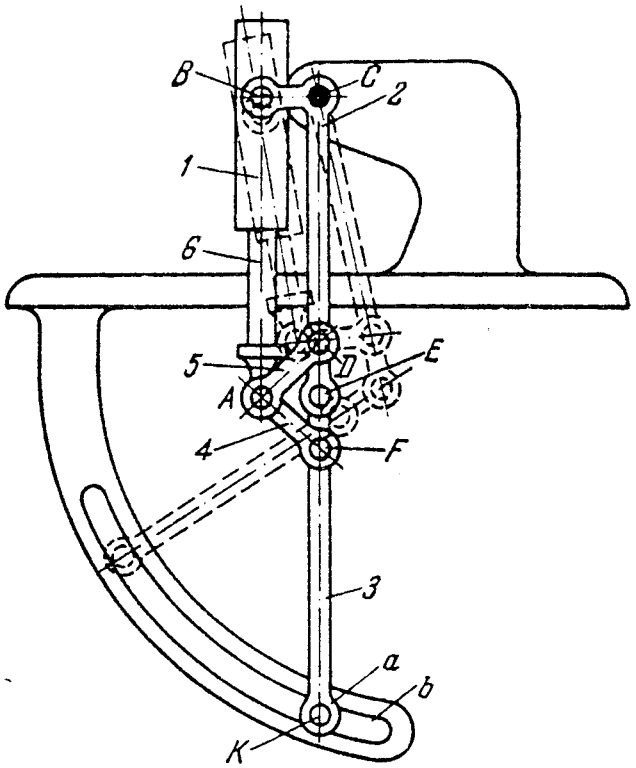

Links *1*, *2*, *3* and *4*, slide in fixed guides *m*, *q*, *p* and *n*. Cross-shaped link *5*, turning about fixed axis *A*, has slots *a*, *b*, *c* and *d* into which pins *e*, *f*, *k* and *h* of links *3*, *2*, *1* and *4* enter. The displacement of links *1*, *2*, *3* and *4* is proportional to the tangent of the angle of rotation of the cross-shaped link.

| 1041 | LINK-GEAR FOLDING-BRACE MECHANISM | LG ML |
|---|---|---|



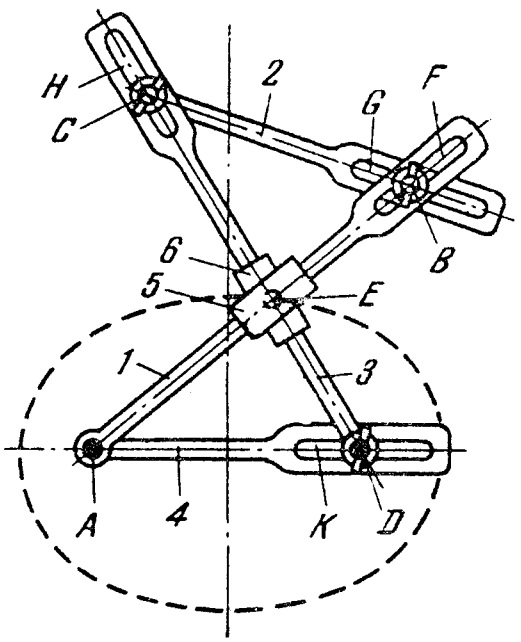

Bent lever *4* turns about fixed axis *C*. Cylinder *1* is connected by turning pair *B* to lever *4*. Rod *6* of the piston sliding in cylinder *1* is connected by turning pair *A* to links *2* and *3*. Links *3* and *2* are connected by turning pairs *D* and *F* to lever *4* and link *5*. Link *5* is connected by turning pair *E* to lever *4* and has pin *a* at point *K* which slides along fixed circular slot *b*. When piston *6* moves out of cylinder *1*, the distance between axes *A* and *B* is increased, and links *2*, *3*, *4* and *5* take the positions shown by the dash lines. In the working position of the brace, points *C*, *D*, *E*, *F* and *K* are on a straight line.

| 1042 | LINK-GEAR FOLDING-BRACE MECHANISM | LG ML |
|---|---|---|

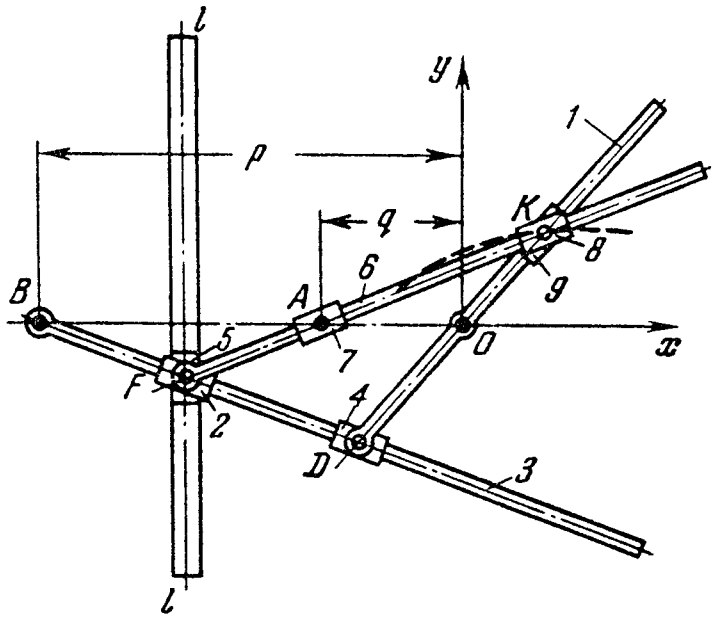



Bent lever *2* turns about fixed axis *C*. Cylinder *1* is connected by turning pair *B* to lever *2*. Rod *6* of the piston sliding in cylinder *1* is connected by turning pair *A* to links *4* and *5*. Links *5* and *4* are connected by turning pairs *D* and *F* to lever *2* and link *3*. Link *3* is connected by turning pair *E* to lever *2* and has pin *a* at point *K* which slides along fixed circular slot *b*. When piston *6* moves into cylinder *1*, the distance between axes *A* and *B* is reduced, and links *2*, *3*, *4* and *5* take the positions shown by the dash lines. In the working position of the brace, points *C*, *D*, *E*, *F* and *K* are on a straight line.

| 1043 | ARTOBOLEVSKY LINK-GEAR ELLIPSOGRAPH | LG Ge. |
|---|---|---|



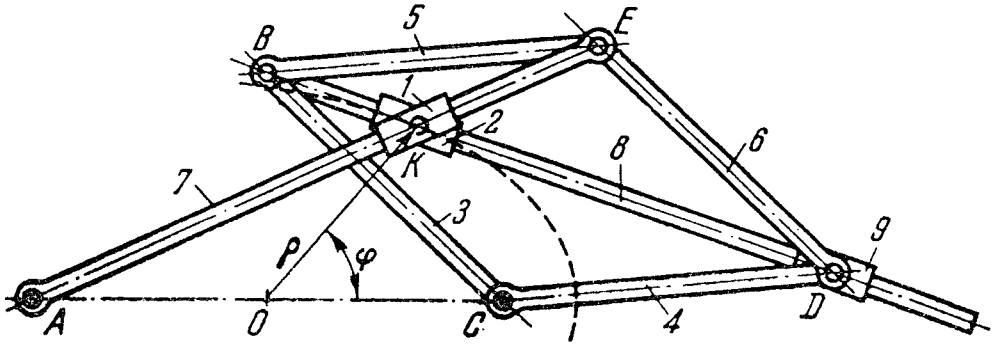

The mechanism is based on crossed-crank linkage *ABCD* with the small link fixed. Added to the linkage is a double guiding element consisting of two sliders, *5* and *6*, connected together by turning pair *E*. The mechanism is intended for tracing ellipses. Pivots *A* and *D* are placed at the foci of the ellipse. The tracing point is at the centre of pivot *E*. Ellipses of various sizes can be obtained by properly selecting the lengths of links *1*, *2*, *3* and *4*. The lengths are varied by moving pivots *B*, *C* and *D* as required along slots *F*, *G*, *H* and *K* of links *1*, *2*, *3* and *4*.




Link *3*, turning about fixed axis *B*, is connected by sliding pairs to sliders *2* and *4*. Slider *2* is connected by a turning pair to slider *5* which moves along fixed guide *l-l*. Link *6*, connected by turning pair *F* to slider *2*, moves in slider *7* which turns about fixed axis *A*. Link *1*, turning about fixed axis *O*, is connected by turning pair *D* to slider *4*. Sliders *8* and *9*, connected together by turning pair *K*, move along the axes of links *6* and *1*. If $2p > q > 0$ then, when sliding link *1* rotates about axis *O*, point *K* describes an ellipse with the equation

$$\frac{x^2}{\frac{(q+r-p)^2\,p^2}{(2p-q)^2}} + \frac{y^2}{\frac{(q+r-p)^2\,q}{2p-q}} = 1$$

where $p = \overline{BO}$
$q = \overline{AO}$
$r = \overline{OD}$.




The lengths of the links comply with the conditions: $\overline{EB} = \overline{BC} = \overline{CD} = \overline{DE}$, so that figure *EBCD* is a rhombus linkage. Links *3* and *4* rotate about fixed axis *C*. Links *5* and *6* are connected by turning pair *E* to link *7* which rotates about fixed axis *A*. Link *8* is connected by turning pair *B* to links *3* and *5*, and moves in slider *2*. Sliders *1* and *2* are connected together by turning pair *K*. Thus the axis of link *8* forms the diagonal *BD* of rhombus linkage *EBCD*. Sliders *1* and *2* move along the axes of links *7* and *8*. When link *7* rotates about axis *A*, point *K* describes an ellipse with the equation

$$\rho = l\sqrt{\frac{l^2 - a^2}{l^2 - a^2\cos\varphi}}$$

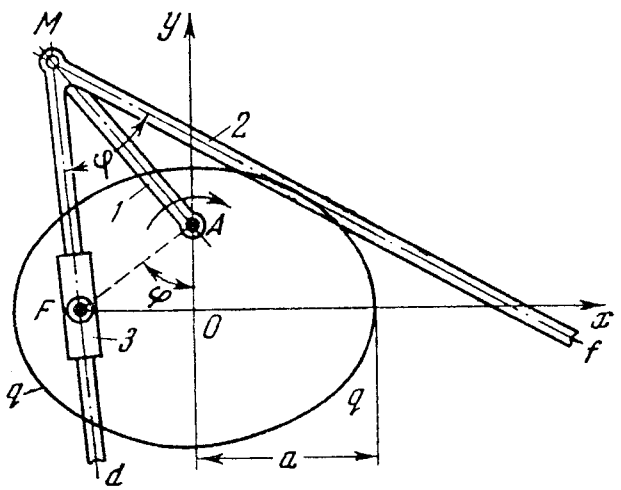
where $2l = \overline{AE}$

$a = \overline{AO} = \overline{OC}$

$\rho$ = radius vector of point *K* in a polar coordinate system with its origin at the middle of line *AC*

$\varphi$ = angle of rotation of radius vector $\rho$ from the initial line.

The condition under which the mechanism will generate ellipses is $l > a$.

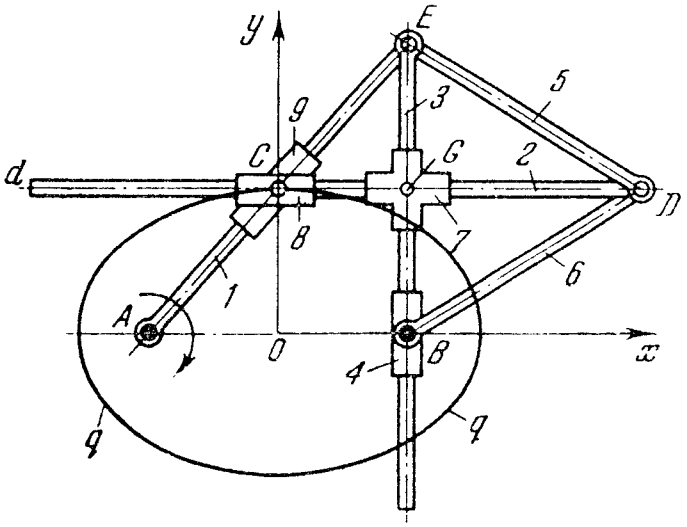



Link *1*, rotating about fixed axis *A*, is connected by turning pair *M* to link *2* which has the form of a bent lever with the angle *dMf*, equal to φ, between the arms. Arm *Md* of link *2* moves in slider *3* which rotates about fixed axis *F*. Centre *F* is placed at one focus of an ellipse and centre *A* on the axis *Oy*, passing through the centre *O* of the ellipse, so that the distance $\overline{AO}$ equals

$$\overline{AO} = \frac{\overline{OF}}{\tan \varphi}$$

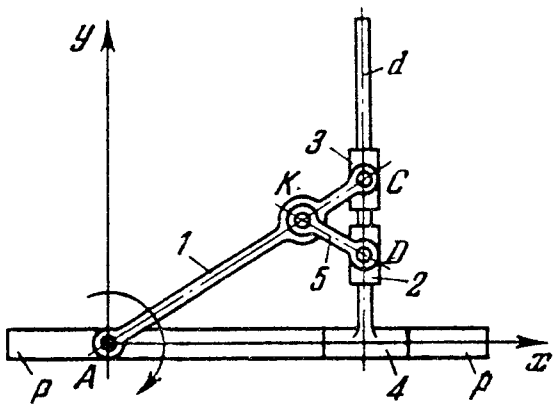
and length $\overline{AM}$ of link *1* is taken equal to $AM = \frac{a}{\sin \varphi}$, where *a* is the major semiaxis of the ellipse. Then, the straight line *Mf* envelops ellipse *q-q* when link *1* rotates about axis *A*.

| 1047 | ARTOBOLEVSKY LINK-GEAR TRACING AND ENVELOPING MECHANISM FOR ELLIPSES AND HYPERBOLAS | LG Ge |
|---|---|---|




Link *1*, rotating about fixed axis *A*, is connected by a sliding pair to slider *9* and by turning pair *E* to link *5*. Link *3* is connected by turning pair *E* to links *5* and *1*, and moves in cross-shaped slider *7* which has guides with axes perpendicular to each other. Link *2* is connected by turning pair *D* to links *5* and *6* and moves in sliders *7* and *8*. Sliders *8* and *9* are connected together by turning pair *C*. Link *6* rotates about fixed axis *B*. Link *3* slides in slider *4* which rotates about fixed axis *B*. Centres *A* and *B* are placed at the foci of an ellipse or hyperbola and the lengths of links *5* and *6* are taken equal ($\overline{ED} = \overline{DB}$). Then, when link *1* rotates, point *C* describes an ellipse or hyperbola and straight line *Dd* envelops the ellipse or hyperbola. As shown, the mechanism is set up for generating ellipse *q-q*. The centre *O* of the ellipse is located in the middle between foci *A* and *B*.

| 1048 | KLEIBER LINK-GEAR ELLIPSOGRAPH | LG<br>Ge |
|---|---|---|

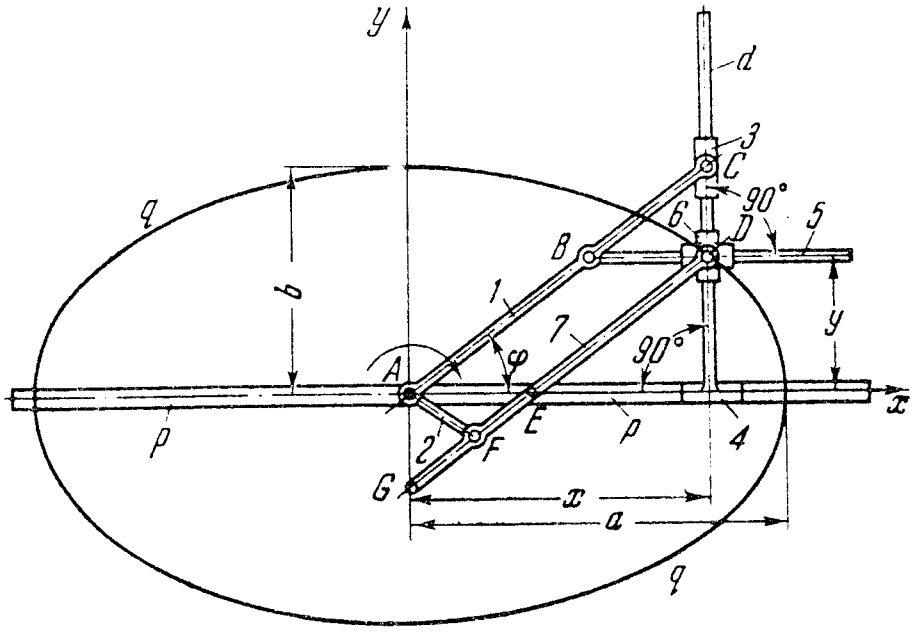



The lengths of the links comply with the conditions: $\overline{AC} = a$, $\overline{AK} - \overline{KC} = b$ and $\overline{KC} = \overline{KD} = \frac{a-b}{2}$. Link *1*, rotating about fixed axis *A*, is connected by turning pairs *K* and *C* to link *5* and slider *3*. Link *5* is connected by turning pair *D* to slider *2*. Sliders *2* and *3* move along bar *d* of slider *4*. Bar *d* is perpendicular to axis *Ax* along which slider *4* moves in fixed guides *p-p*. When link *1* rotates, point *D* describes an ellipse with its centre at point *A* and with the equation

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1.$$

# 1049 KLEIBER LINK-GEAR ELLIPSOGRAPH

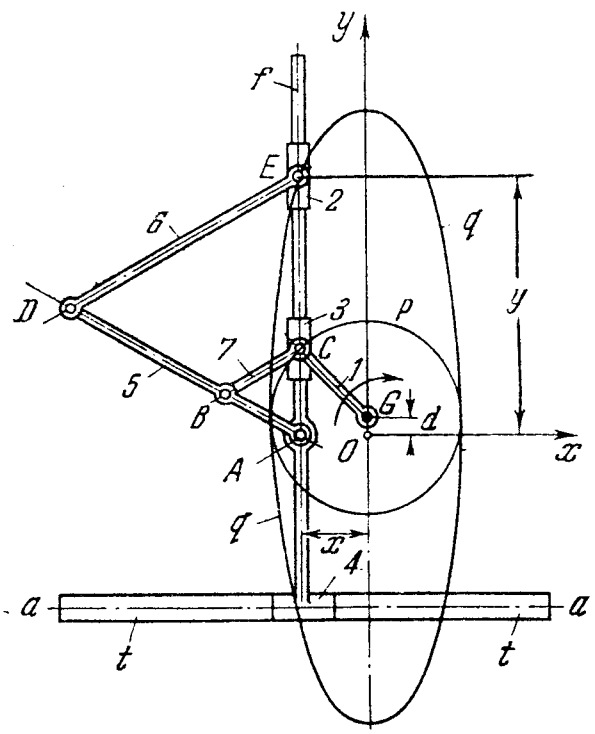
LG Ge




The lengths of the links comply with the conditions: $\overline{FD} = \frac{a+b}{2}$, $\overline{AF} = \frac{a-b}{2}$ and $\overline{GF} = \overline{FE} = \overline{AF}$, where $a$ and $b$ are the semiaxes of the ellipse. Link *1*, rotating about fixed axis $A$, is connected by turning pairs $B$ and $C$ to link *5* and slider *3* which moves along bar $d$ of slider *4*. Link *5* moves in cross-shaped slider *6* which has guides with axes perpendicular to each other. Slider *6* moves along bar $d$ of slider *4* which, in turn, moves along fixed guides $p$-$p$. When link *1* rotates, point $D$ of slider *6* describes ellipse $q$-$q$ whose parametric equations are

$$x = a\cos\varphi \quad \text{and} \quad y = b\sin\varphi$$

where $\varphi$ is the angle between axis $AC$ of link *1* and axis $Ax$ of guides $p$-$p$. If to this basic mechanism one adds link *2*, rotating about fixed axis $A$, and link *7*, connected by turning pairs $F$ and $D$ to link *2* and slider *6*, then points $E$ and $G$ of link *7* move along axes $Ax$ and $Ay$, and therefore any point of link *7* describes an ellipse.



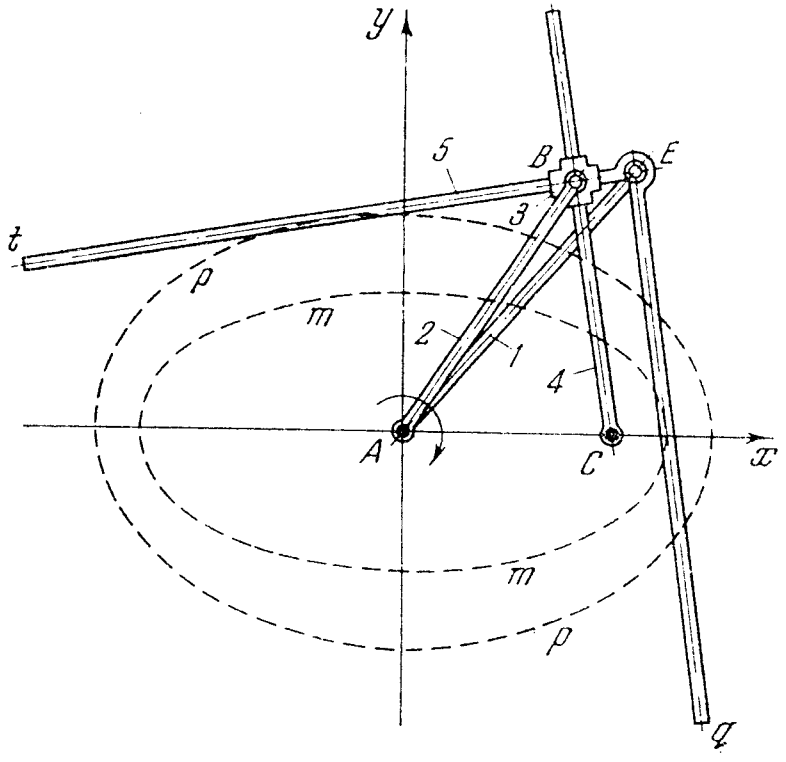

The lengths of the links comply with the conditions: $\overline{AD} = \overline{DE} = m$, $\overline{AB} = \overline{BC} = n$ and $\overline{AD} : \overline{AB} = \overline{DE} : \overline{BD} = k$. Link *1*, rotating about fixed axis *G*, is connected by turning pair *C* to slider *3* which moves along bar *f* of slider *4*. Slider *4* moves along fixed guides *t-t* whose axis *a-a* is parallel to axis *Ox*. Link *5* is connected by turning pairs *A* and *D* to links *4* and *6*. Link *6* is connected by turning pair *E* to slider *2* which moves along bar *f* of slider *4*. When link *1* rotates, point *E* describes ellipse *q-q* whose equation is

$$k^2x^2 + y^2 - 2k\,dy - k^2(R^2 - d^2) = 0$$

where *R* is the radius of the circle described by point *C* of link *1*. Referred to the principal coordinate axes, the equation of ellipse *q-q* is

$$\frac{x^2}{\quad} + \frac{y^2}{k^2R^2} = \quad .$$

| 1051 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR ENVELOPING CONFOCAL ELLIPSES | LG Ge |
|---|---|---|

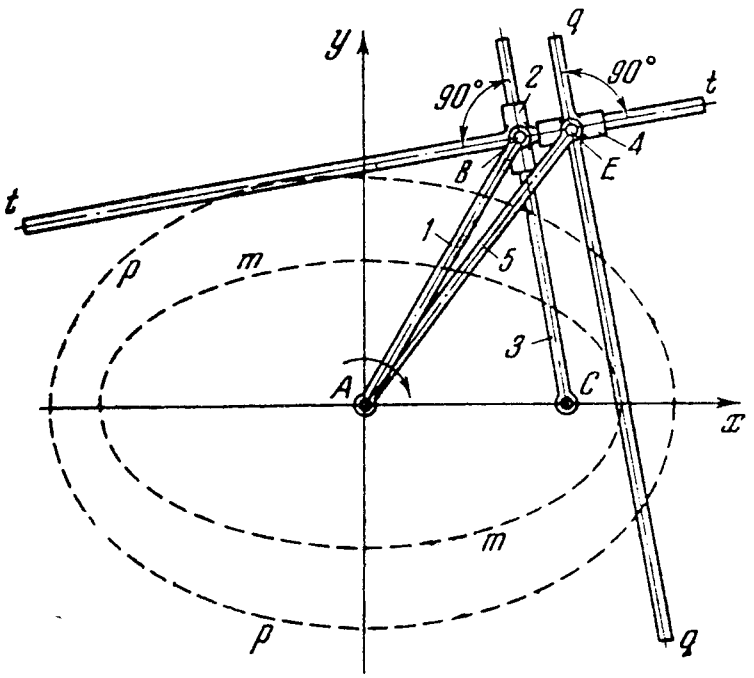



The lengths of the links comply with the conditions:

$$\overline{AB} = a_2 \text{ and } \overline{AE} = \sqrt{a_1^2 + b_2^2} = \sqrt{a_2^2 + b_1^2}$$

where $a_1$ and $b_1$ are the semiaxes of ellipse *m-m*, and $a_2$ and $b_2$ are the semiaxes of ellipse *p-p*. Angle *tEq* equals 90°. Link *1*, rotating about fixed axis *A*, is connected by turning pair *E* to link *5* which has the form of bent lever *tEq*. Link *4*, rotating about fixed axis *C*, is connected by a sliding pair to cross-shaped slider *3* which has guides with axes perpendicular to each other. Arm *Et* of link *5* moves in slider *3*. Link *2*, rotating about axis *A*, is connected by turning pair *B* to slider *3*. Point *A* is placed at the common centre of ellipses *m-m* and *p-p*, and point *C* at one of their common foci. Then, when link *1* rotates, the arms of the right angle *tEq* of link *5* simultaneously envelop the confocal ellipses *m-m* and *p-p*.

| 1052 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR ENVELOPING CONFOCAL ELLIPSES | LG Ge |
|---|---|---|

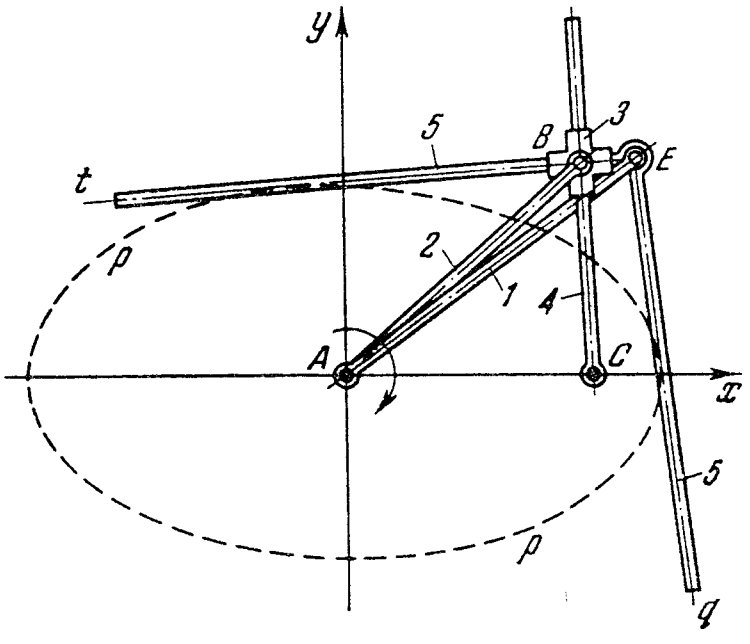



The lengths of the links comply with the conditions:

$$\overline{AB} = a_2 \text{ and } \overline{AE} = \sqrt{a_1^2 + b_2^2} = \sqrt{a_2^2 + b_1^2}$$

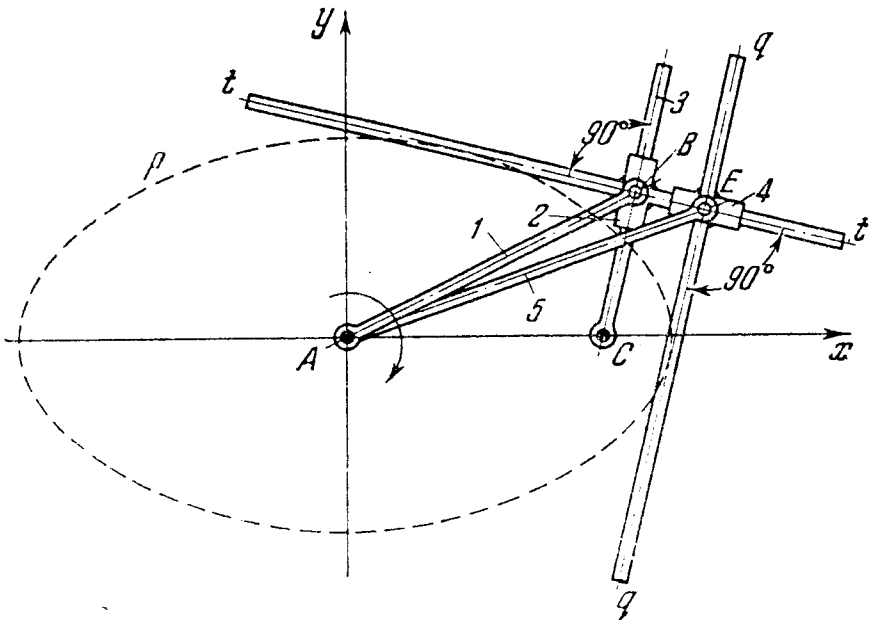
where $a_1$ and $b_1$ are the semiaxes of ellipse *m-m*, and $a_2$ and $b_2$ are the semiaxes of ellipse *p-p*. Link *1*, rotating about fixed axis *A*, is connected by turning pair *B* to slider *2* which moves along the axis of link *3*. Link *3* rotates about fixed axis *C*. Link *5*, rotating about fixed axis *A*, is connected by turning pair *E* to slider *4* which moves along axis *t-t* of the cross-piece of slider *2*. Point *A* is placed at the common centre of ellipses *m-m* and *p-p*, and point *C* at one of their common foci. Then, when link *1* rotates, axes *t-t* and *q-q* of the cross-pieces of sliders *2* and *4* simultaneously envelop the confocal ellipses *m-m* and *p-p*.

| 1053 | ARTOBOLEVKSY LINK-GEAR ELLIPSE ENVELOPMENT MECHANISM | LG Ge |
|---|---|---|



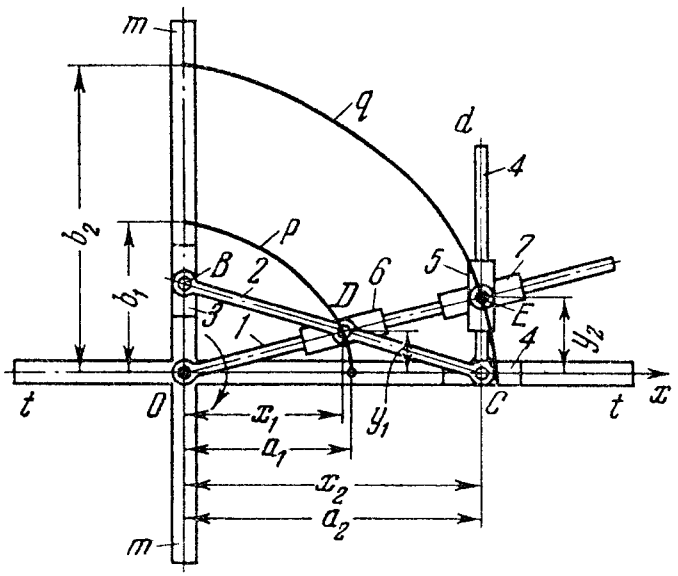

The lengths of the links comply with the conditions: $\overline{AC} = a$ and $\overline{AE} = \sqrt{a^2 + b^2}$, where $a$ and $b$ are the major and minor semiaxes of the ellipse being enveloped, and angle $tEq = 90°$. Link *1*, rotating about fixed axis *A*, is connected by turning pair *E* to link *5* which has the form of bent lever *tEq*. Link *4*, rotating about fixed axis *C*, is connected by a sliding pair to cross-shaped slider *3* which has guides with axes perpendicular to each other. Arm *Et* of link *5* moves in slider *3*. Link *2*, rotating about axis *A*, is connected by turning pair *B* to slider *3*. Point *A* is placed at the centre of the ellipse and point *C* at one of its foci. Then, when link *1* rotates, the arms of the right angle *tEq* of link *5* simultaneously envelop ellipse *p-p*.

| 1054 | ARTOBOLEVSKY LINK-GEAR ELLIPSE ENVELOPMENT MECHANISM | LG Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AB} = a$ and $\overline{AE} = \sqrt{a^2 + b^2}$, where $a$ and $b$ are the major and minor semiaxes of the ellipse being enveloped. Link *1*, rotating about fixed axis *A*, is connected by turning pair *B* to slider *2* which moves along the axis of link *3*. Link *3* rotates about fixed axis *C*. Link *5*, rotating about axis *A*, is connected by turning pair *E* to slider *4* which moves along axis *t-t* of the cross-piece of slider *2*. Point *A* is placed at the centre of the ellipse and point *C* at one of its foci. Then, when link *1* rotates, axes *t-t* and *q-q* of the cross-pieces of sliders *2* and *4* simultaneously envelope ellipse *p-p*.

| 1055 | LINK-GEAR ELLIPSOGRAPH | LG Ge |
|---|---|---|




Link *1*, rotating about fixed axis *O*, is connected by sliding pairs to sliders *6* and *7*. Link *2* is connected by turning pair *D* to slider *6* and by turning pairs *B* and *C* to sliders *3* and *4* which move along two guides *m-m* and *t-t* perpendicular to each other. Slider *5* is connected by turning pair *E* to slider *7* and slides along bar *d* of slider *4*. When link *1* rotates, point *D* describes ellipse *p-p*, and point *E* describes ellipse *q-q*. The equation of ellipse *p-p* is

$$\frac{x_1}{a_1^2}+\frac{y_1}{b_1^2}=1$$

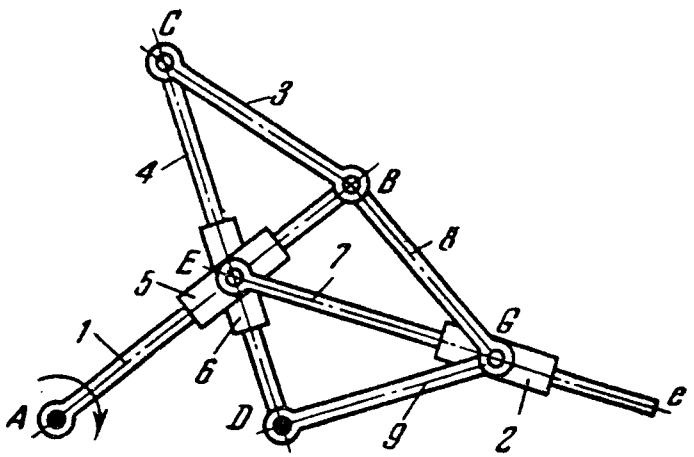
where $a_1 = \overline{BD}$ and $b_1 = \overline{DC}$. The equation of ellipse *q-q* is

$$\frac{x_2}{a_2^2}+\frac{y_2}{b_2^2}=1$$

where $a_2 = a_1 + b_1$ and $b_2=\frac{b_1}{a_1}(a_1 + b_1)$. Therefore, the parameters of ellipses *p-p* and *q-q* are related by the condition

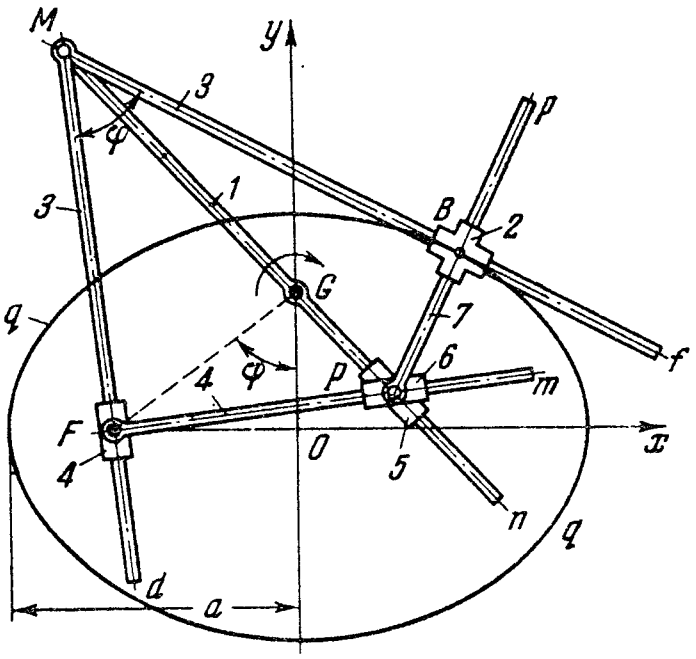
$$\frac{a_1}{a_2}=\frac{b_1}{b_2}.$$

| 1056 | ARTOBOLEVSKY LINK-GEAR TRACING AND ENVELOPING MECHANISM FOR ELLIPSES | LG Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$, $\overline{CB} = \overline{AD}$, $\overline{CB} = \overline{GD}$ and $\overline{AB} > \overline{BC}$. Figure $ABCD$ is a crossed-crank linkage. Link *1*, rotating about fixed axis $A$, is connected by a sliding pair to slider *5* and by turning pairs $B$ to links *3* and *8*. Link *4*, rotating about fixed axis $D$, is connected by a sliding pair to slider *6* and by turning pair $C$ to link *3*. Sliders *5* and *6* are connected together by turning pair $E$. Link *9*, turning about axis $D$, is connected by turning pairs $G$ to link *8* and slider *2* which moves along axis $Ee$ of link *7*. Link *7* is connected by turning pair $E$ to sliders *5* and *6*. Centres $A$ and $D$ are placed at the foci of an ellipse. Then, when link *1* rotates, point $E$ describes the ellipse, and straight line $Ee$ envelops this ellipse.

| 1057 | ARTOBOLEVSKY LINK-GEAR TRACING AND ENVELOPING MECHANISM FOR ELLIPSES | LG Ge |
|---|---|---|

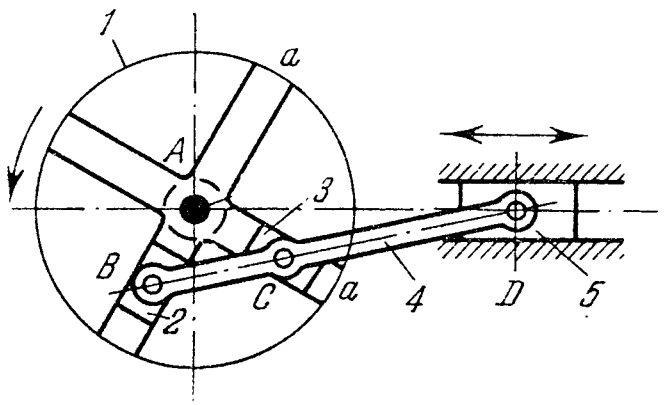



Link *1*, rotating about fixed axis *G*, is connected by turning pair *M* to link *3* which has the form of bent lever *dMf* with the angle φ between the arms. Arm *Md* of link *3* moves in slider *4* which rotates about fixed axis *F*, and arm *Mf* slides in cross-shaped slider *2* which has guides with axes perpendicular to each other. Sliders *6* and *5* are connected together by turning pair *P*. They slide in directions *Fm* and *Gn* along links *4* and *1*. Centre *F* is placed at one focus of an ellipse and centre *G* on axis *Oy*, passing through the centre of the ellipse, so that the distance *GO* equals

$$\overline{GO} = \frac{\overline{OF}}{\tan\varphi}.$$

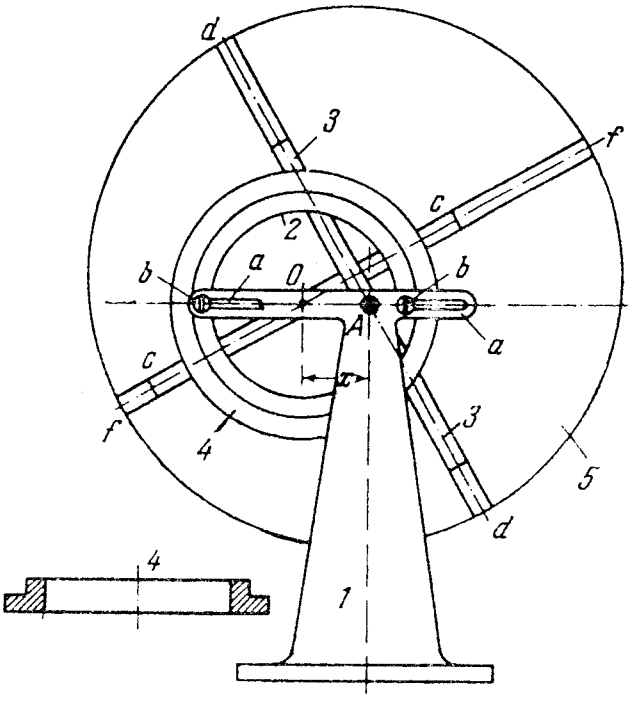
The length $\overline{GM}$ on link *1* is taken equal to $\overline{GM} = \frac{a}{\sin\varphi}$, where *a* is the major semiaxis of the ellipse. Then, when link *1* rotates, straight line *Mf* envelops ellipse *q-q* and point *B* of slider *2*, at the intersection of directions *P* and *Mf*, describes ellipse *q-q*.

| 1058 | LINK-GEAR INVERTED ELLIPSOGRAPH MECHANISM | LG Ge |
|---|---|---|



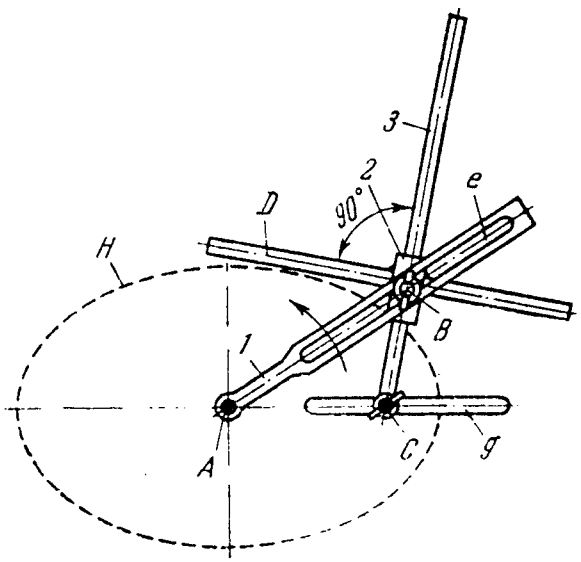

Disk *1* has two mutually perpendicular diametral grooves *a*. Sliders *2* and *3* move along these grooves. Link *4* is connected by turning pair *D* to slider *5* which moves along fixed guides. If slider *5* is removed and disk *1* is held stationary, the mechanism is converted into an ellipsograph (elliptic trammel) in which all points of link *4* describe ellipses. In one revolution of shaft *A*, piston *5* has two double strokes (back and forth).

| 1059 | LEONARDO DA VINCI'S SLOTTED-LINK ELLIPSOGRAPH | LG Ge |
|---|---|---|

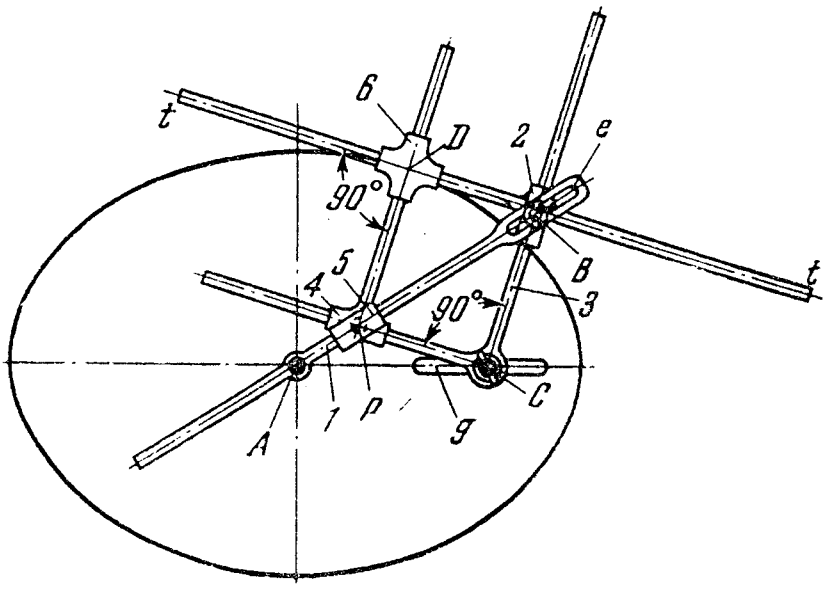



Ring *2* is secured by screws *b* to upright *1* which has slots *a* for this purpose. Ring *2* can be set to any position along slots *a* to obtain the required coordinate *x* which is equal to $\overline{AO}$ where *O* is the centre of ring *2*. Rotating about fixed axis *A* is slider *3* which moves along groove *d-d* of disk *5*. Slider *4*, designed as a ring encircling fixed ring *2*, has extensions *c* that fit in groove *f-f* of disk *5*. The axes of grooves *d-d* and *f-f* are perpendicular to each other. When slider *3* rotates about axis *A*, a pencil clamped on upright *1* describes an ellipse on disk *5* which rotates about axis *A* and slides along the axes of its grooves *d-d* and *f-f*. The size of the ellipse depends upon the preset distance *x*.

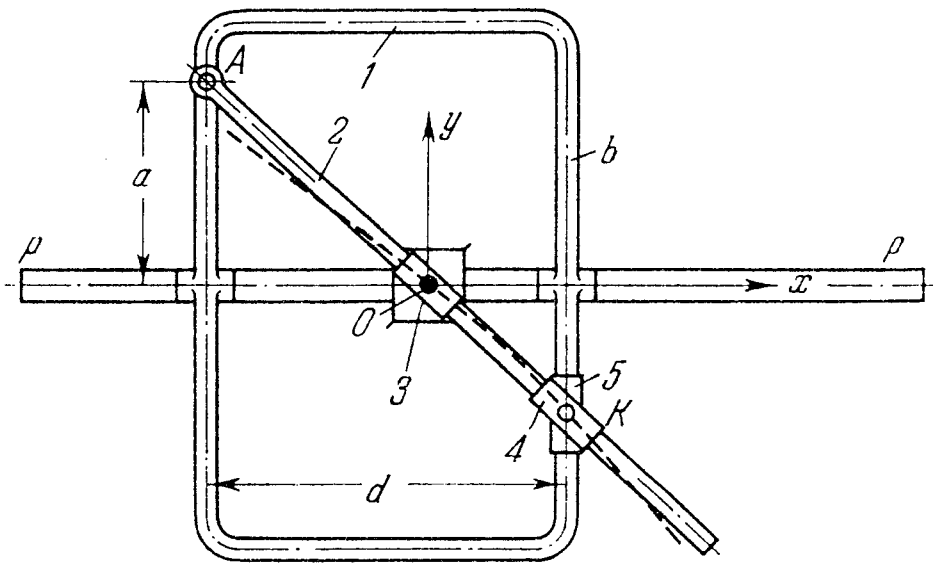
| 1060 | ARTOBOLEVSKY LINK-GEAR ELLIPSE ENVELOPMENT MECHANISM | LG Ge |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AC} < \overline{AB}$. Crank *1*, of length $\overline{AB}$, rotates about fixed axis *A*. Sliding link *3* rotates about fixed axis *C*. Slider *2*, moving along link *3*, carries rule *D*. When crank *1*, whose length $\overline{AB}$ is changed by adjusting pivot *B* along slot *e*, rotates about axis *A*, rule *D*, secured rigidly to slider *2*, envelops ellipse *H*. The length of the major axis of the ellipse is twice that of the crank length $\overline{AB}$. The centre of pivot *C* is located at one focus of the ellipse and the centre of pivot *A* at its centre. Ellipses of the required parameters can be obtained by adjusting pivots *B* and *C* along slots *e* and *g*.




This mechanism is based on the four-bar slotted-link ellipse envelopment mechanism *ABC*. Added to this linkage is a double guiding element consisting of two sliders, *4* and *5*, connected together by turning pair *P*. Point *P* traces the space centroid of slider *2*. Sliders *2* and *4* are connected by sliding pairs to cross-shaped slider *6* which has guides with axes perpendicular to each other. When link *1* rotates about fixed axis *A*, centre *D* of cross-shaped slider *6* describes an ellipse and, simultaneously, rule *t-t*, secured rigidly to slider *2*, envelops the ellipse. The length of the major axis of the ellipse is twice length $\overline{AB}$ of crank *1*. Pivot *C* is placed at one focus of the ellipse and pivot *A* at its centre. Ellipses of the required parameters can be obtained by adjusting pivots *B* and *C* along slots *e* and *g*.

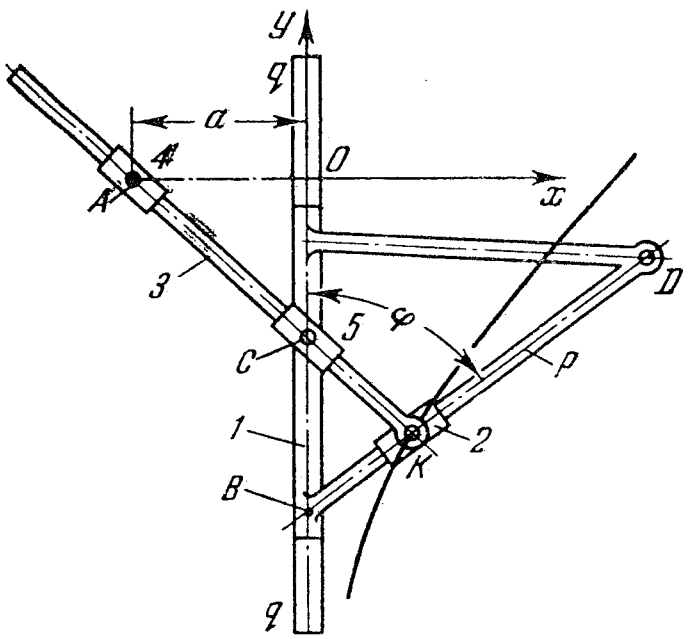



Frame *1* slides in fixed guides *p-p*. Link *2* is connected by turning pair *A* to frame *1* and moves in slider *3* which rotates about fixed axis *O*. Sliders *4* and *5* are connected together by turning pair *K*. Slider *4* moves along the axis of link *2*, and slider *5* moves along side *b* of frame *1*. When frame *1* moves along guides *p-p*, point *K* describes a hyperbola whose equation is

$$y = \frac{xa}{d - x}$$

where $a$ = distance of point *A* from axis *x-x* of guides *p-p*
$d$ = distance between the vertical sides of frame *1*.

| 1063 | ROTH LINK-GEAR HYPERBOLOGRAPH | LG<br>Ge |
|---|---|---|




Slider *1* moves along fixed guides *q-q*. Rigidly secured to slider *1* is cross-piece *p* along which slider *2* moves. Link *3* is connected by turning pair *K* to slider *2* and by sliding pairs to sliders *4* and *5*. Slider *5* is connected by turning pair *C* to slider *1*. Slider *4* turns about fixed axis *A*. When slider *1* moves along guides *q-q*, point *K* describes a hyperbola with the equation

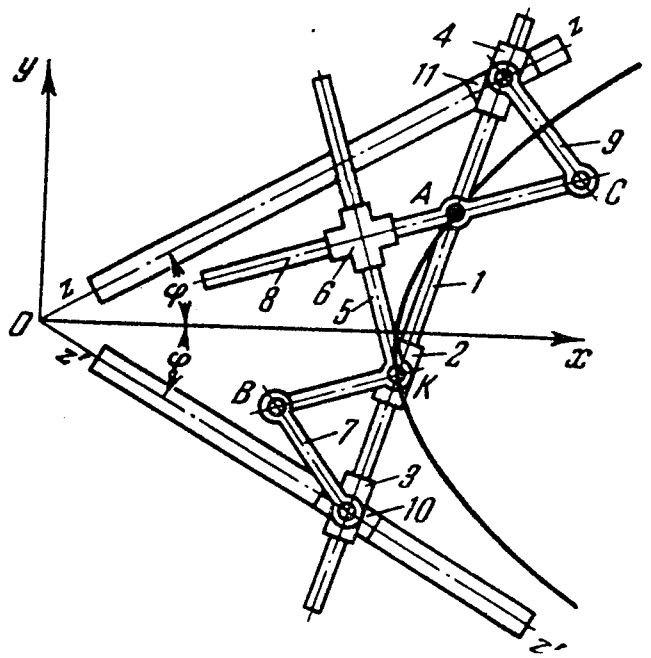
$$x^2 - xy \tan \varphi + (k \tan \varphi - a)\, x + ak \tan \varphi = 0$$

where $a$ = distance between point *A* and the axis of fixed guides *q-q*

$k = \overline{CB}$

$\varphi$ = angle between the axes of guides *q-q* and *p-p*.

| 1064 | VYATKIN LINK-GEAR HYPERBOLOGRAPH | LG Ge |
|---|---|---|

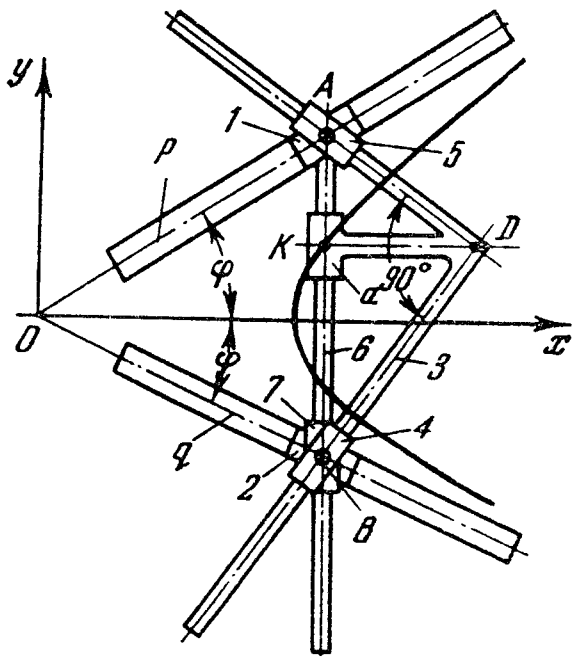



Sliding link *1* rotates about fixed axis *A*. Sliders *2*, *3* and *4* move along link *1*. Slider *2* is connected by turning pair *K* to link *5* which moves in cross-shaped slider *6*. Also moving in slider *6* is link *8* which turns about fixed axis *A* and is connected by turning pair *C* to link *9*. Outmost links *7* and *9* are connected by turning pairs to sliders *3*, *10*, *4* and *11*. Sliders *11* and *10* move along fixed guides *z*-*z* and *z'*-*z'*. When sliding link *1* rotates, point *K* describes a hyperbola with the equation

$$\frac{x^2}{a^2 - \dfrac{k^2}{\tan^2 \varphi}} - \frac{y^2}{a^2 \tan^2 \varphi - k^2} = 1$$

where $(a, k)$ = coordinates of fixed point *A*
$\varphi$ = angle between guides *z*-*z* or *z'*-*z'* and the positive direction of the *x*-axis.

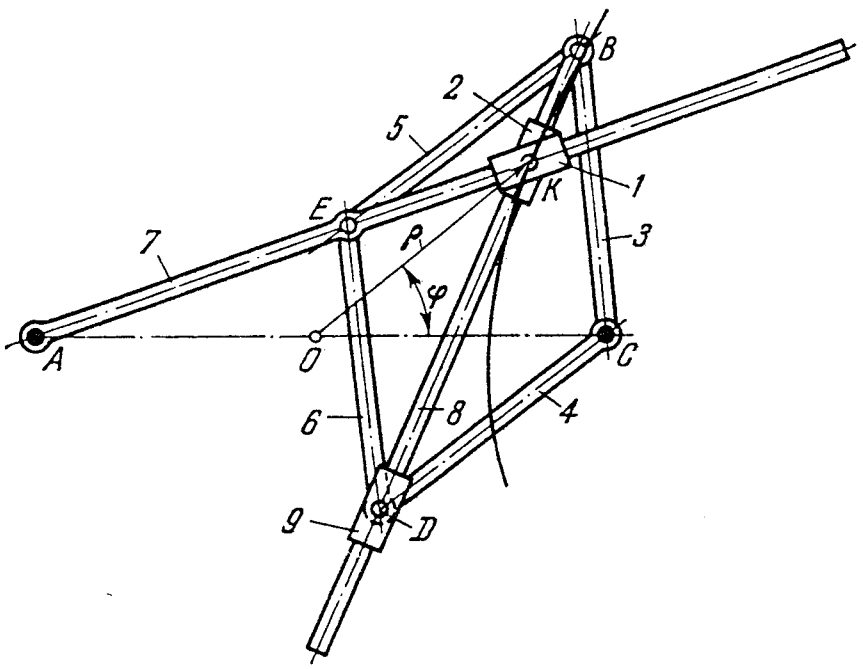
| 1065 | VYATKIN LINK-GEAR HYPERBOLOGRAPH | LG<br>Ge |
|---|---|---|




Sliders *1* and *2* slide along fixed guides $p$ and $q$ whose axes make angles $\varphi$ with axis $Ox$. Bent lever *3* moves in sliders *5* and *4* which are connected by turning pairs $A$ and $B$ to sliders *1* and *2*. Link *6* moves in guide $a$ of lever *3* and in slider *7* which is connected by turning pair $B$ to link *4*. When points $A$ and $B$ move along guides $p$ and $q$, point $K$ describes a hyperbola with the equation

$$\frac{x^2}{\left(\frac{a}{\tan\varphi}\right)^2} - \frac{y^2}{a^2} = 1$$

where $a = \overline{KD}$.




The lengths of the links comply with the conditions: $\overline{EB} = \overline{BC} = \overline{CD} = \overline{DE}$, i.e. figure *EBCD* is a rhombus linkage. Links *3* and *4* turn about fixed axis *C*. Links *5* and *6* are connected by turning pairs *E* to link *7* which turns about fixed axis *A*. Link *8* is connected by turning pair *B* to links *3* and *5*, and moves in slider *9* which is connected by turning pair *D* to links *4* and *6*. Thus the axis of link *8* forms the diagonal *BD* of rhombus linkage *EBCD*. Sliders *1* and *2*, connected together by turning pair *K*, move along the axes of links *7* and *8*. When link *7* turns about axis *A*, point *K* describes a hyperbola with the equation

$$\rho = l\sqrt{\frac{a^2 - l^2}{a^2\cos^2\varphi - l^2}}$$

where $a = \overline{AO} = \overline{OC}$

$2l = \overline{AE}$

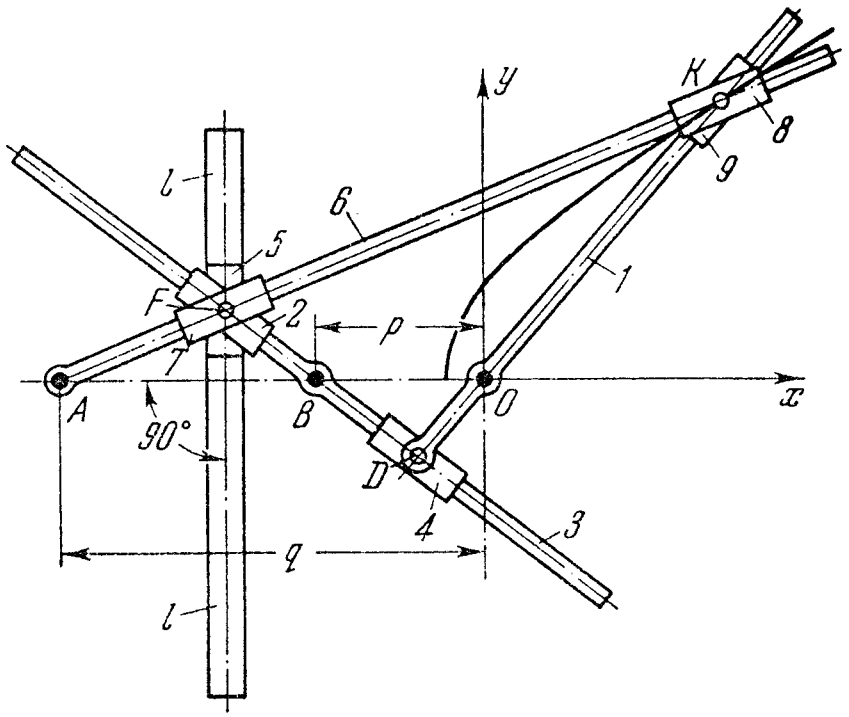
$\rho$ = radius vector of point *K* with respect to the origin of coordinates *O*, located at the middle of length $\overline{AC}$

$\varphi$ = angle of rotation of radius vector $\rho$ from the polar axis.

For the mechanism to generate a hyperbola, it is necessary that

$$l < a.$$

| 1067 | LINK-GEAR HYPERBOLOGRAPH | LG<br>Ge |
|---|---|---|

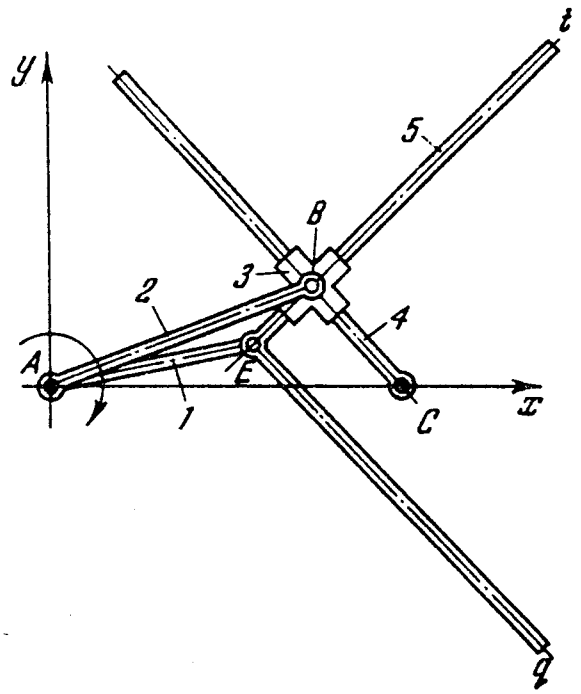



Link *3*, turning about fixed axis *B*, is connected by sliding pairs to sliders *2* and *4*. Slider *2* is connected by turning pair *F* to slider *5* which moves along fixed guides *l-l*. Link *6*, turning about fixed axis *A*, moves in slider *7* which is connected by turning pair *F* to slider *5*. Link *1*, turning about fixed axis *O*, is connected by turning pair *D* to slider *4*. Sliders *8* and *9*, connected together by turning pair *K*, move along the axes of links *6* and *1*. If $q > 2p$ and $q > 0$, then, when sliding link *1* turns about axis *O*, point *K* describes a portion of a hyperbola with the equation

$$\frac{x^2}{\frac{(q-p-r)^2\,p^2}{(q-2p)^2}} - \frac{y^2}{\frac{(q-p-r)^2\,q}{q-2p}} = 1$$

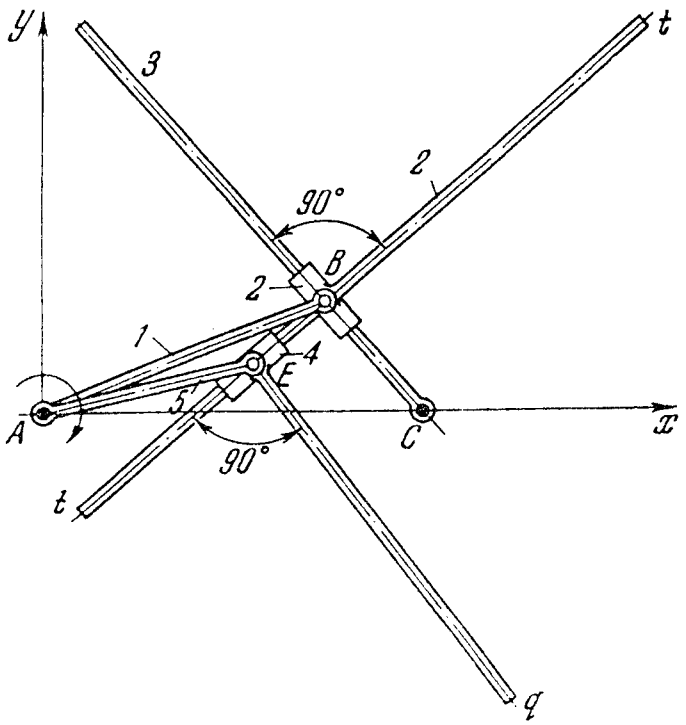
where $p = \overline{BO}$
$q = \overline{OA}$
$r = \overline{OD}$.

| 1068 | LINK-GEAR HYPERBOLA ENVELOPMENT MECHANISM | LG Ge |
|---|---|---|



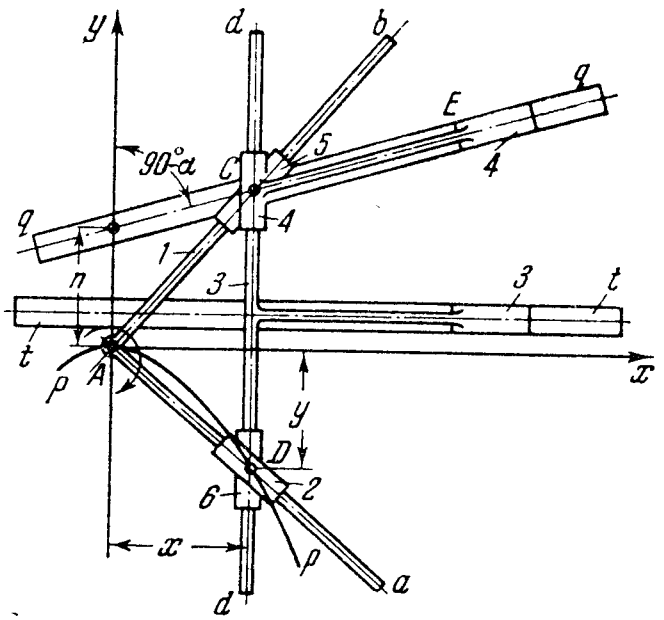

The lengths of the links comply with the conditions: $\overline{AB} = a$, $\overline{AE} = \sqrt{a^2 - b^2}$ and $a > b$, where $a$ and $b$ are the transverse and conjugate semiaxes of the hyperbola to be enveloped and angle $tEq = 90°$. Link *1*, turning about fixed axis *A*, is connected by turning pair *E* to link *5* which is designed as the bent lever *tEq*. Link *4*, turning about fixed axis *C*, is connected by a sliding pair to cross-shaped slider *3* which has guides with axes perpendicular to each other. Arm *Et* of link *5* moves in slider *3*. Link *2*, turning about axis *A*, is connected by turning pair *B* to slider *3*. Point *A* is placed at the centre of a hyperbola and point *C* at one of its foci. Then, when link *1* turns about axis *A*, the arms of right angle *tEq* of link *5* simultaneously envelop the hyperbola. The mechanism can envelop only portions of the hyperbola.

| 1069 | LINK-GEAR HYPERBOLA ENVELOPMENT MECHANISM | LG Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AB} = a$, $\overline{AE} = \sqrt{a^2 - b^2}$ and $b < a$, where $a$ and $b$ are the transverse and conjugate semiaxes of the hyperbola to be enveloped. Link *1*, turning about fixed axis $A$, is connected by turning pair $B$ to slider *2*. Slider *2* moves along the axis of link *3* which turns about fixed axis $C$. Link *5*, turning about axis $A$, is connected by turning pair $E$ to slider *4* which moves along axis *t-t* of the cross-piece of slider *2*. Point $A$ is placed at the centre of a hyperbola and point $C$ at one of its foci. Then, when link *1* turns about axis $A$, the axes *t-t* and *E-q* of the cross-pieces of sliders *2* and *4* simultaneously envelop the hyperbola. The mechanism can envelop only portions of the hyperbola.

| 1070 | ARTOBOLEVSKY LINK-GEAR HYPERBOLOGRAPH | LG Ge |
|---|---|---|




Link *1*, designed as bent lever *bAa*, turns about fixed axis *A*, and its arm *Aa* moves in slider *2* and arm *Ab* in slider *5*. Slider *2* is connected by turning pair *D* to slider *6* which moves along cross-piece *d-d* of slider *3*. Slider *3* moves along fixed guides *t-t* whose axis is parallel to axis *Ax*. Slider *5* is connected by turning pair *C* to slider *4* which moves along fixed guides *q-q*. The axis of guides *q-q* makes the angle $\alpha$ with axis *Ax*. When link *1* turns about axis *A*, point *D* describes hyperbola *p-p* with the equation

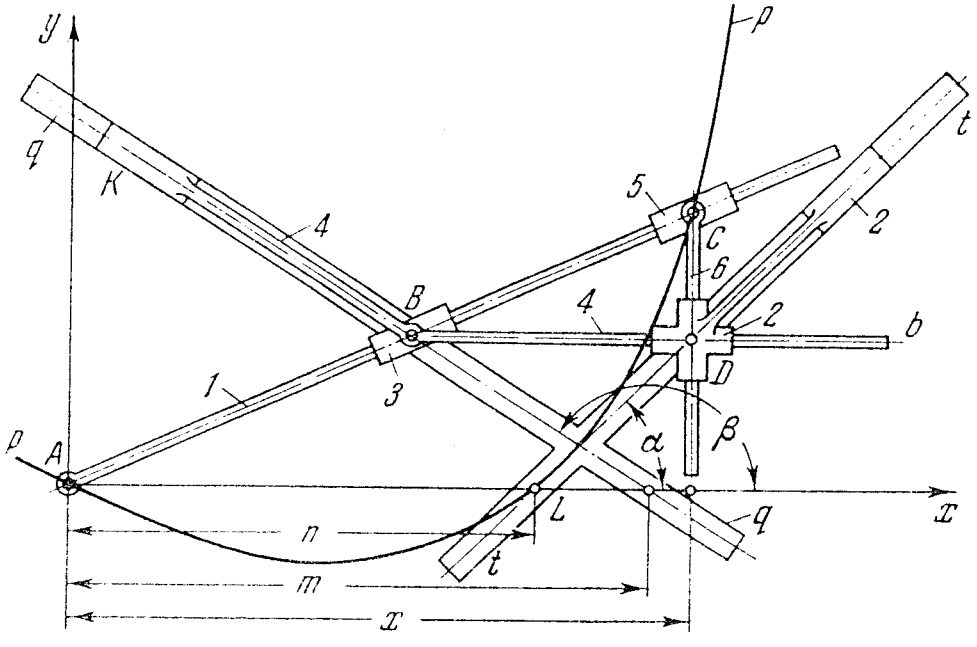
$$x^2 + Bxy + 2Ey = 0$$

where $B = -\tan\alpha$

$E = \frac{n}{2}$

$n$ = constant dimension of the mechanism.

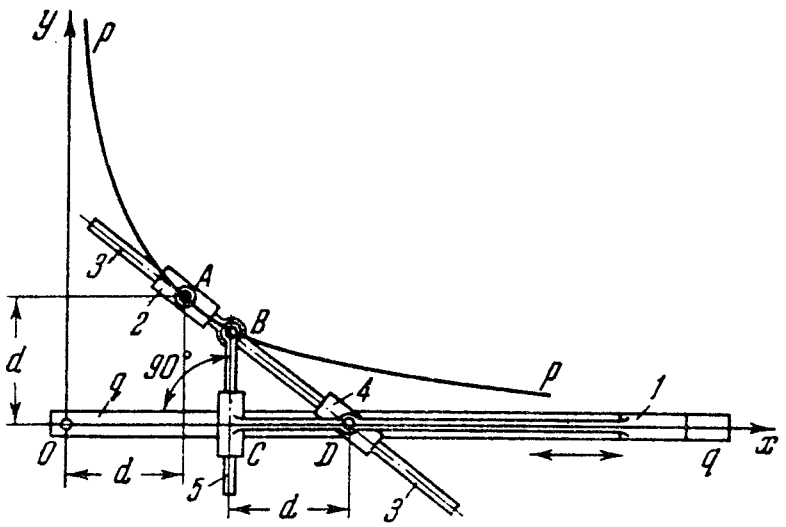
| 1071 | LINK-GEAR HYPERBOLOGRAPH | LG<br>Ge |
|---|---|---|




Link *1*, rotating about fixed axis *A*, is connected by sliding pairs to sliders *3* and *5*. Slider *3* is connected by turning pair *B* to slider *4* which moves along fixed guides *q-q*. The axis of guides *q-q* makes the angle $\beta = 135°$ with axis *Ax* and with cross-piece *Bb*. Cross-piece *Bb* moves in cross-shaped slider *2* which has guides with axes perpendicular to each other. Slider *2* moves along fixed guides *t-t* whose axis makes the angle $\alpha = 45°$ with axis *Ax*. Link *6* is connected by turning pair *C* to slider *5* and moves in slider *2*. When link *1* turns about axis *A*, point *C* describes hyperbola *p-p* with the equation

$$x^2 + xy - nx - (m + n)\, y = 0$$

where *m* and *n* are constant dimensions of the mechanism.

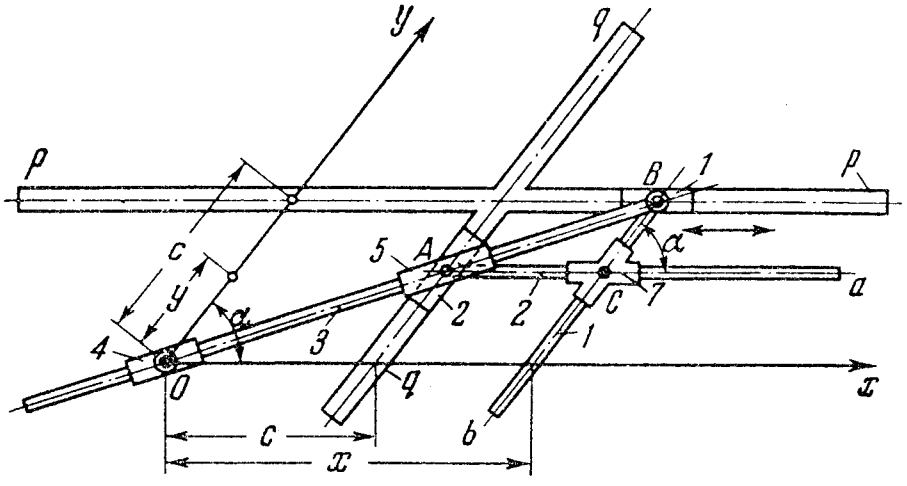



Slider *1*, sliding in fixed guides *q-q*, is connected by turning pair *D* to slider *4* and by a sliding pair to link *5*. Link *5* is connected by turning pair *B* to link *3*. Link *3* moves in slider *4* and in slider *2* which turns about fixed axis *A*. When slider *1* moves along guides *q-q*, point *B* describes equilateral hyperbola *p-p* with the equation

$$xy = d^2$$

where $d$ is a constant dimension of the mechanism. Axes *Ox* and *Oy* are asymptotes of hyperbola *p-p*.

| 1073 | DOBROVOLSKY LINK-GEAR HYPERBOLOGRAPH | LG Ge |
|---|---|---|

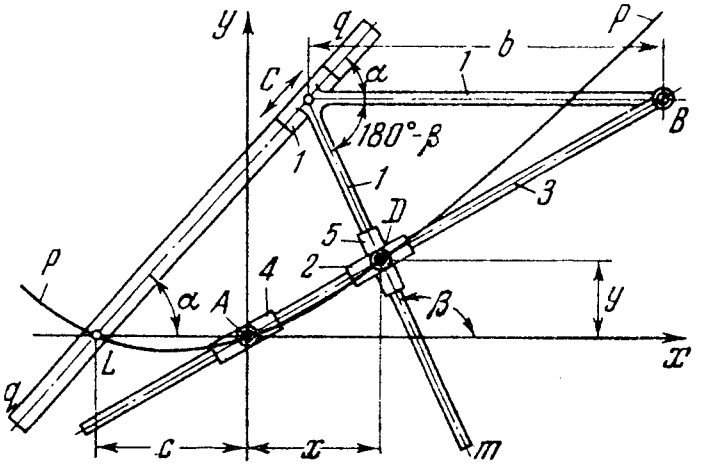



Slider *1*, moving along fixed guides *p-p*, has cross-piece *Bb* which is connected by a sliding pair to X-shaped slider *7* having the angle $\alpha$ between the axis of its guides. Link *3*, connected by turning pair *B* to slider *1*, moves in sliders *5* and *4*. Slider *5* is connected by turning pair *A* to slider *2* which moves along fixed guides *q-q*. Cross-piece *Aa* of slider *2* moves in slider *7*. Slider *4* turns about fixed axis *O*. When slider *1* moves along guides *p-p*, point *C* describes an equilateral hyperbola with the equation

$$xy = c^2 = \frac{1}{4}(a^2 + b^2)$$

where $c$ = constant dimension of the mechanism
$a$ and $b$ = semiaxes of the hyperbola.

Axes *Ox* and *Oy* are asymptotes of the hyperbola.




Slider *1*, moving along fixed guides ***q-q***, has cross-piece *CB* which is connected by turning pair *B* to link *3*, and cross-piece *Cm* which moves in slider *5*. Link *3* is connected by a sliding pair with slider *2* and moves in slider *4* which turns about fixed axis *A*. Sliders *2* and *5* are connected together by turning pair *D*. When slider *1* moves along guides *q-q*, point *D* describes hyperbola *p-p* with the equation

$$ex^2 + efxy + y^2 + 2gx + 2hy = 0$$

where $e = \tan\alpha \tan\beta$

$$f = -\frac{\tan\alpha + \tan\beta}{2}$$

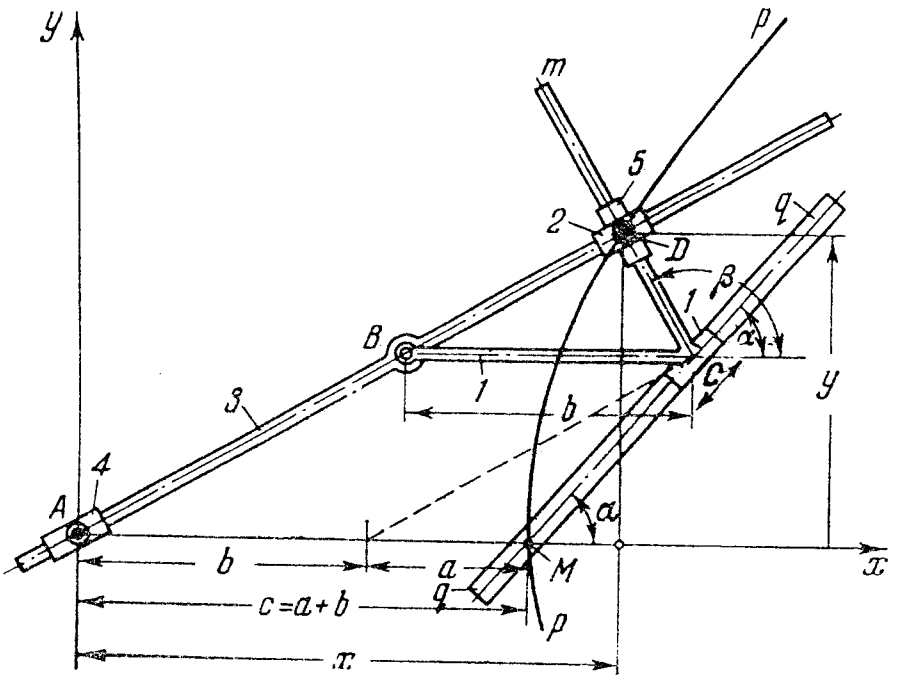
$$g = \frac{c \tan\alpha \tan\beta}{2}$$

$$h = \frac{(b-c)\tan\alpha - b\tan\beta}{2}$$

$b$ and $c$ = constant dimensions of the mechanism.
The axis of guides *q-q* makes the angle $\alpha$ with the direction *CB* and axis *Ax*. The axis of cross-piece *Cm* of slider *1* makes the angle $\beta$ with axis *Ax* and angle $180°-\beta$ with the direction *CB*. If $c = 0$, $\alpha = 45°$ and $\beta = 135°$, then point *D* describes an equilateral hyperbola with the equation

$$-y^2 - 2by = 0.$$

| 1075 | ARTOBOLEVSKY LINK-GEAR HYPERBOLOGRAPH | LG Ge |
|---|---|---|




Slider *1*, moving along fixed guides *q-q*, has cross-piece *CB* which is connected by turning pair *B* to link *3*, and cross-piece *Cm* which moves in slider *5*. Link *3*, connected by a sliding pair to slider *2*, moves in slider *4* which turns about fixed axis *A*. Sliders *2* and *5* are connected together by turning pair *D*. When slider *1* moves along guides *q-q*, point *D* describes hyperbola *p-p* with the equation

$$ex^2 + efxy + ky^2 + 2gx + 2hy = 0$$

where $e = \tan\alpha \tan\beta$

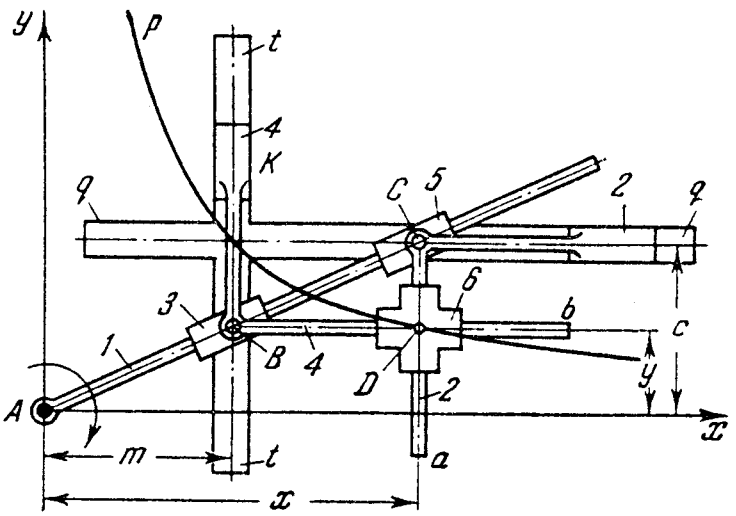
$$f = -\frac{\tan\alpha + \tan\beta}{2}$$

$$g = -\frac{(2a+b)\tan\alpha\tan\beta}{2}$$

$$k = 1$$

$$h = \frac{2a\tan\alpha - b\tan\beta}{2}$$

$b$ and $a$ = constant dimensions of the mechanism.
The axis of guides *q-q* makes the angle $\alpha$ with the direction *BC* and axis *Ax*. The axis of cross-piece *Cm* of slider *1* makes the angle $\beta$ with axis *Ax* and angle $180° - \beta$ with the direction *BC*.

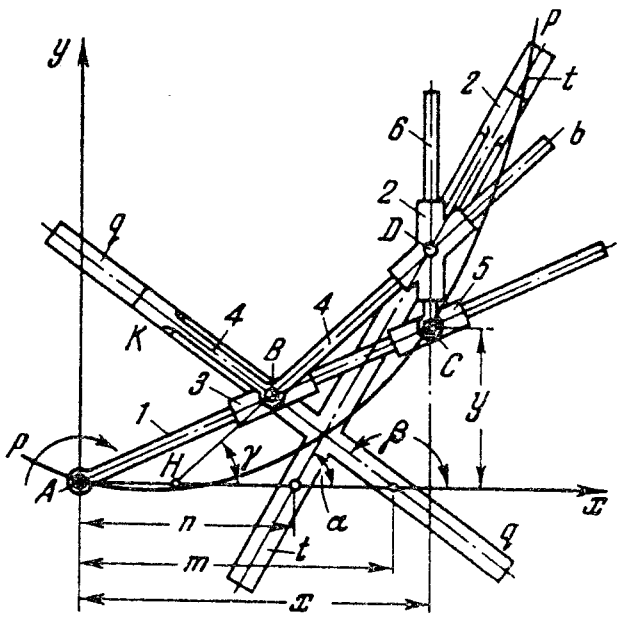



Link *1*, turning about fixed axis *A*, is connected by sliding pairs to sliders *3* and *5*. Slider *3* is connected by turning pair *B* to slider *4* which moves along fixed guides *t-t*. The axis of guides *t-t* is parallel to axis *Ay*. Cross-piece *Bb* of slider *4* is connected by a sliding pair to cross-shaped slider *6* which has guides with axes perpendicular to each other. Slider *2* moves along fixed guides *q-q* whose axis is parallel to axis *Ax*. Cross-piece *Ca* of slider *2* moves in slider *6*. When link *1* turns about axis *A*, point *D*, at the intersection of *Bb* and *Ca*, describes equilateral hyperbola *p-p* with the formula

$$xy = cm$$

where $c$ and $m$ are constant dimensions of the mechanism. Axes *Ax* and *Ay* are asymptotes of hyperbola *p-p*.

| 1077 | LINK-GEAR HYPERBOLOGRAPH MECHANISM | LG Ge |
|---|---|---|




Link *1*, turning about fixed axis *A*, is connected by sliding pairs to sliders *3* and *5*. Slider *3* is connected by turning pair *B* to slider *4* which moves along fixed guides *q-q*. The axis of guides *q-q* makes the angle β with axis *Ax*. Cross-piece *Bb* of slider *4* moves in X-shaped slider *2* which has guides with axes making the angle $90° - \gamma$ with each other. Slider *2* moves along fixed guides *t-t* whose axis makes the angle α with axis *Ax*. Link *6* is connected by turning pair *C* to slider *5* and moves in slider *2*. When link *1* turns about axis *A*, point *C* describes hyperbola *p-p* with the equation

$$ex^2 + fxy + 2gx + 2hy = 0$$

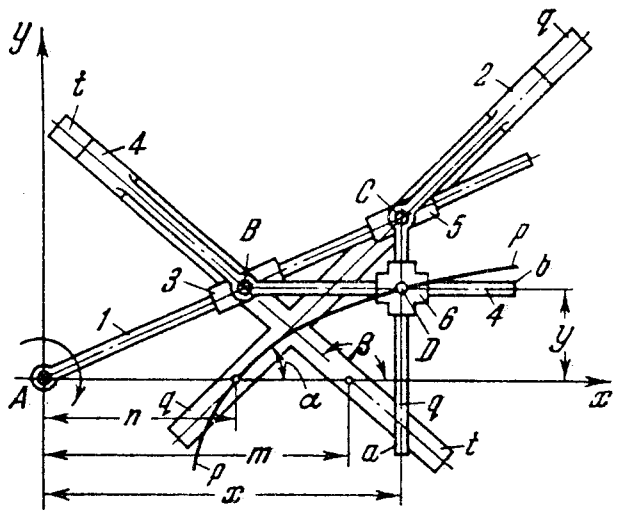
where $e = (\tan\alpha - \tan\gamma)\tan\beta$

$$f = -(\tan\alpha - \tan\gamma)$$

$$g = \frac{m\tan\gamma - n\tan\alpha}{2}$$

$$h = -\frac{m\tan\beta - n\tan\alpha}{2}$$

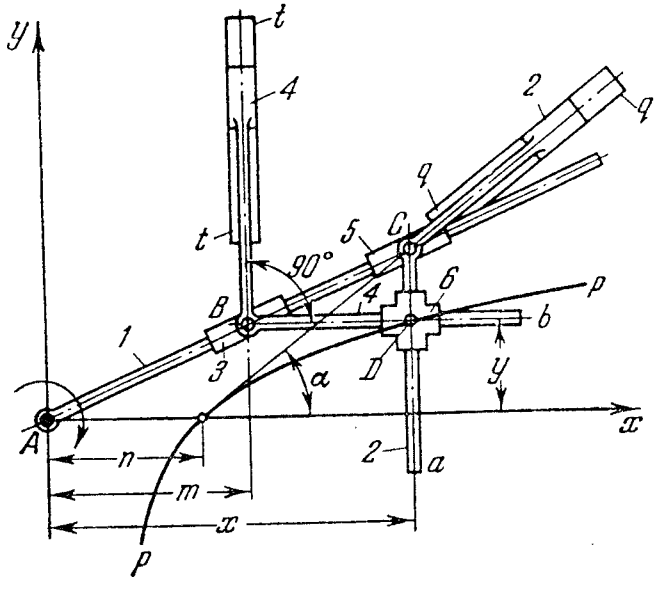
*m* and *n* = constant dimensions of the mechanism.




Link *1*, turning about fixed axis *A*, is connected by sliding pairs to sliders *3* and *5*. Slider *3* is connected by turning pair *B* to slider *4* which moves along fixed guides *t-t*. The axis of guides *t-t* makes the angle $\beta = 135°$ with axis *Ax*. Cross-piece *Bb* of slider *4* is connected by a sliding pair to cross-shaped slider *6* which has guides with axes perpendicular to each other. Slider *2* moves along fixed guides *q-q* whose axis makes the angle $\alpha = 45°$ with axis *Ax*. Cross-piece *Ca* of slider *2* moves in slider *6*. The axes of guides *t-t* and *q-q* are perpendicular to each other. When link *1* turns about axis *A*, point *D* of slider *6*, at the intersection of *Bb* and *Ca*, describes equilateral hyperbola *p-p* with the equation

$$2xy - mx - ny + mn = 0$$

where *m* and *n* are constant dimensions of the mechanism.




Link *1*, turning about fixed axis *A*, is connected by sliding pairs to sliders *3* and *5*. Slider *3* is connected by turning pair *B* to slider *4* which moves along fixed guides *t-t*. The axis of guides *t-t* makes the angle 90° with axis *Ax*. Cross-piece *Bb* of slider *4* is connected by a sliding pair to cross-shaped slider *6* which has guides with axes perpendicular to each other. Slider *2* moves along fixed guides *q-q* whose axis makes the angle $\alpha$ with axis *Ax*. Cross-piece *Ca* of slider *2* moves in slider *6*. When link *1* turns about axis *A*, point *D* of slider *6*, at the intersection of *Bb* and *Ca*, describes equilateral hyperbola *p-p* with the equation

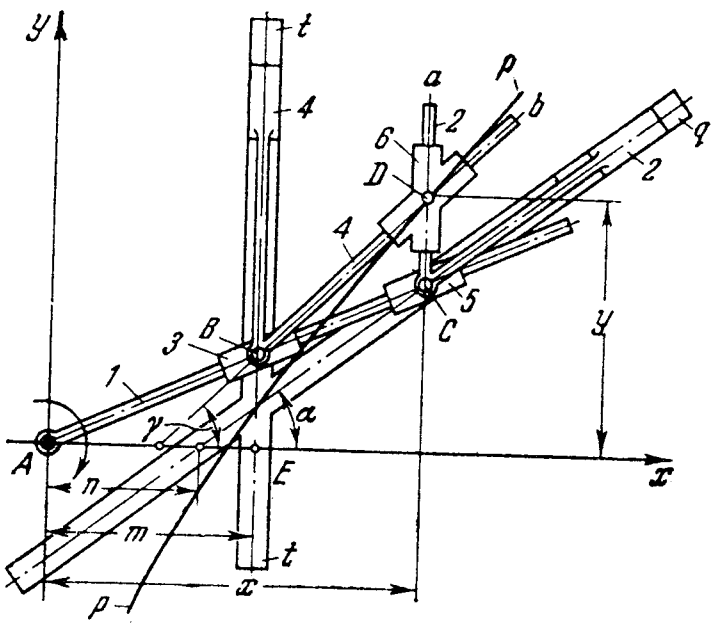
$$exy + 2fx + g = 0$$

where $e = -1$

$$f = \frac{m \tan \alpha}{2}$$

$$g = -\frac{mn \tan \alpha}{2}$$

$m$ and $n$ = constant dimensions of the mechanism.




Link *1*, turning about fixed axis *A*, is connected by sliding pairs to sliders *3* and *5*. Slider *3* is connected by turning pair *B* to slider *4* which moves along fixed guides *t-t*. The axis of guides *t-t* makes the angle 90° with axis *Ax*. Cross-piece *Bb* of slider *4* is connected by a sliding pair to X-shaped slider *6* which has guides making the angle $90° - \gamma$ with each other. Slider *2* moves along fixed guides *q-q* whose axis makes the angle $\alpha$ with axis *Ax*. Cross-piece *Ca* of slider *2* moves in slider *6*. When link *1* turns about axis *A*, point *D* of slider *6*, at the intersection of lines *Bb* and *Ca*, describes hyperbola *p-p* with the equation

$$ex^2 + fxy + 2gx + h = 0$$

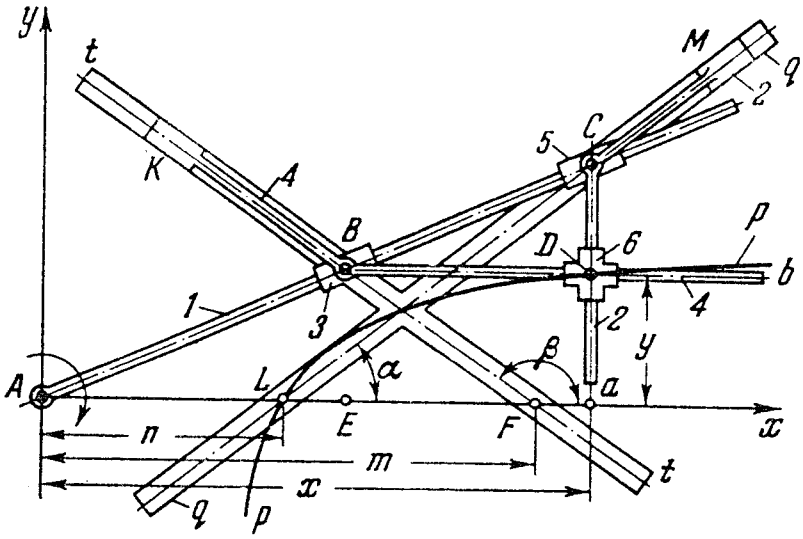
where $e = \tan\gamma$

$f = -1$

$$g = \frac{m(\tan\gamma - \tan\alpha)}{2}$$

$h = -mn\tan\alpha$

*m* and *n* = constant dimensions of the mechanism.




Link *1*, turning about fixed axis *A*, is connected by sliding pairs to sliders *3* and *5*. Slider *3* is connected by turning pair *B* to slider *4* which moves along fixed guides *t-t*. The axis of guides *t-t* makes the angle β with axis *Ax*. Cross-piece *Bb* of slider *4* is connected by a sliding pair to cross-shaped slider *6* which has guides with axes perpendicular to each other. Slider *2* moves along fixed guides *q-q* whose axis makes the angle α with axis *Ax*. Cross-piece *Ca* of slider *2* moves in slider *6*. When link *1* turns about axis *A*, point *D* of slider *6*, at the intersection of lines *Bb* and *Ca*, describes hyperbola *p-p* with the equation

$$gxy + 2hx + 2ey + f = 0$$

where $g = -(\tan\beta - \tan\alpha)$

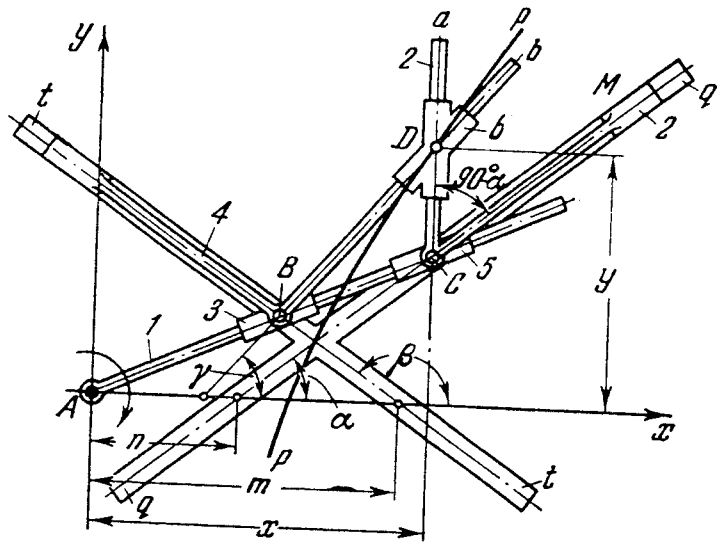
$$h = \frac{m \tan\alpha \tan\beta}{2}$$

$$e = -\frac{n \tan\alpha}{2}$$

$$f = -mn \tan\alpha \tan\beta$$

$m$ and $n$ = constant dimensions of the mechanism.

| 1082 | LINK-GEAR HYPERBOLOGRAPH MECHANISM | LG Ge |
|---|---|---|




Link *1*, turning about fixed axis *A*, is connected by sliding pairs to sliders *3* and *5*. Slider *3* is connected by turning pair *B* to slider *4* which moves along fixed guides *t-t*. The axis of guides *t-t* makes the angle β with axis *Ax*. Cross-piece *Bb* of slider *4* is connected by a sliding pair to X-shaped slider *6* which has guides making the angle $90° - \gamma$ with each other, where γ is the angle made by cross-piece *Bb* with axis *Ax*. Slider *2* moves along fixed guides *q-q* whose axis makes the angle α with axis *Ax*. Cross-piece *Ca* of slider *2* moves in slider *6*. When link *1* turns about axis *A*, point *D* of slider *6*, at the intersection of lines *Bb* and *Ca*, describes hyperbola *p-p* with the equation

$$ex^2 + fxy + 2gx + 2hy + j = 0$$

where $e = (\tan\beta - \tan\alpha)\tan\beta$

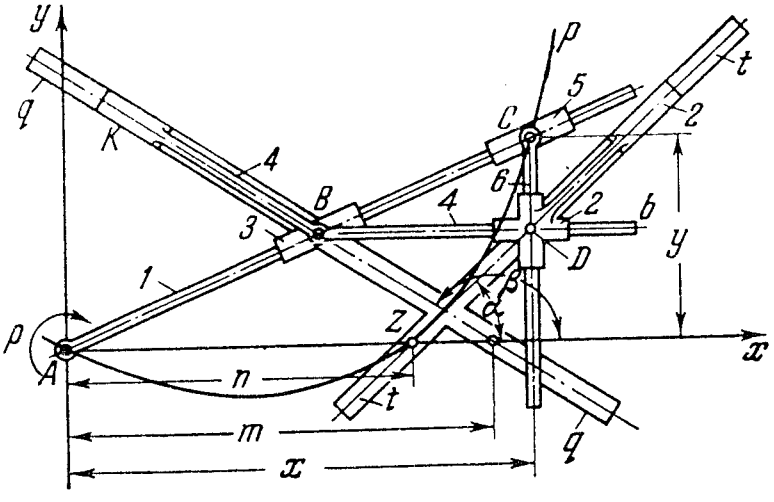
$f = -(\tan\beta - \tan\alpha)$

$g = -\dfrac{m\tan\beta\tan\gamma - n\tan\alpha\tan\gamma - m\tan\alpha\tan\beta}{2}$

$h = -n\tan\alpha$

$j = -mn\tan\alpha\tan\beta$

*n* = constant dimensions of the mechanism.




Link *1*, turning about fixed axis *A*, is connected by sliding pairs to sliders *3* and *5*. Slider *3* is connected by turning pair *B* to slider *4* which moves along fixed guides *q-q*. The axis of guides *q-q* makes the angle β with axis *Ax*. Cross-piece *Bb* of slider *4* is connected by a sliding pair to cross-shaped slider *2* which has guides with axes perpendicular to each other. Slider *2* moves along fixed guides *t-t* whose axis makes the angle α with axis *Ax*. Link *6*, connected by turning pair *C* to slider *5*, moves in slider *2*. When link *1* turns about axis *A*, point *C* describes hyperbola *p-p* with the equation

$$ex^2 + fxy + 2gx + 2hy = 0$$

where $e = \tan\alpha \tan\beta$

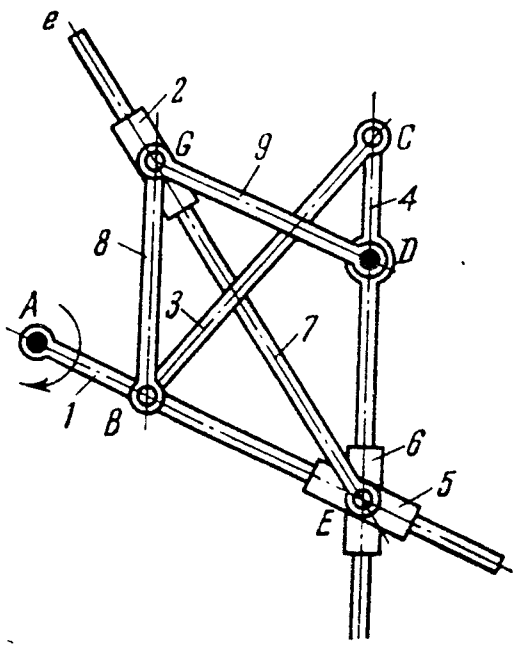
$f = \tan\alpha$

$$g = \frac{n \tan\alpha \tan\beta}{2}$$

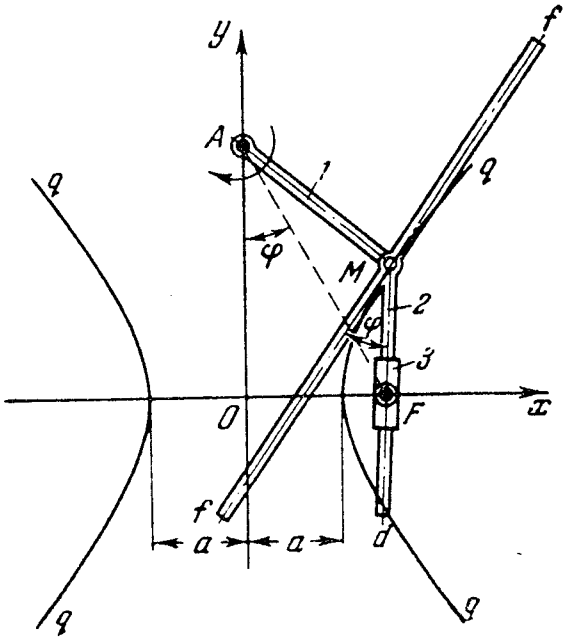
$$h = \frac{m \tan\beta - n \tan\alpha}{2}$$

*m* and *n* = constant dimensions of the mechanism.

| 1084 | LINK-GEAR TRACING AND ENVELOPING MECHANISM FOR HYPERBOLAS | LG Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$, $\overline{BC} = \overline{AD}$, $\overline{GB} = \overline{GD}$ and $\overline{AB} < \overline{BC}$. Figure $ABCD$ is a crossed-crank linkage. Link *1*, turning about fixed axis $A$, is connected by a sliding pair to slider *5* and by turning pairs $B$ to links *3* and *8*. Link *4*, turning about fixed axis $D$, is connected by a sliding pair to slider *6* and by turning pair $C$ to link *3*. Sliders *5* and *6* are connected together by turning pair $E$. Link *9*, turning about axis $D$, is connected by turning pairs $G$ to link *8* and slider *2*. Slider *2* moves along axis $Ee$ of link *7* which is connected by turning pair $E$ to sliders *5* and *6*. Centres $A$ and $D$ are placed at the foci of a hyperbola. Then point $E$ describes the hyperbola and straight line $Ee$ envelops this hyperbola.



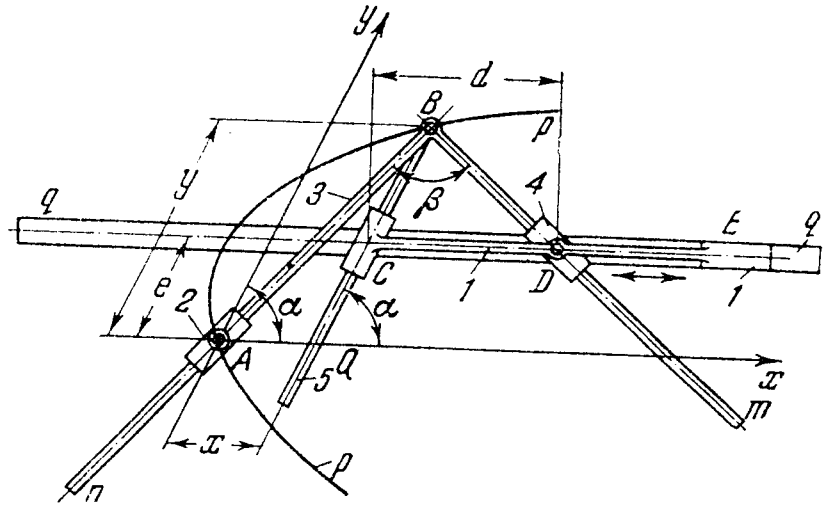

Link *1*, turning about fixed axis *A*, is connected by turning pair *M* to link *2* which has the form of a bent lever with the angle *dMf* equal to φ. Arm *Md* of link *2* moves in slider *3* which turns about fixed axis *F*. Centre *F* is placed at one of the foci of a hyperbola, centre *A* is placed on axis *Oy*, passing through the centre of the hyperbola, at the distance

$$\overline{AO} = \frac{\overline{OF}}{\tan\varphi}$$

and the length $\overline{AM}$ of link *1* is taken equal to $\overline{AM} = \frac{a}{\sin\varphi}$,

where *a* is the transverse semiaxis of the hyperbola. Then, when link *1* turns about axis *A*, straight line *f-f* envelops hyperbola *q-q*.

| 1086 | LEBEAU LINK-GEAR HYPERBOLOGRAPH | LG<br>Ge |
|---|---|---|

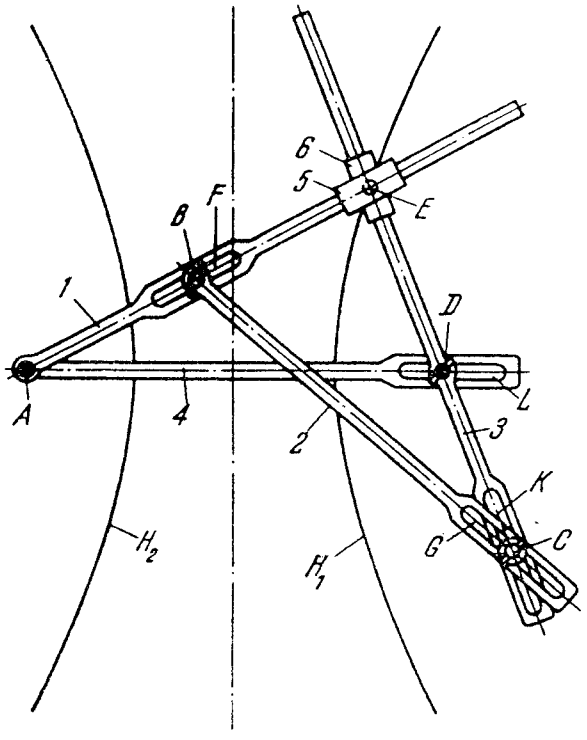



Slider *1*, moving along fixed guides *q-q*, is connected by turning pair *D* to slider *4* and by a sliding pair to link *5*. Link *5* is connected by turning pair *B* to link *3* which has the form of bent lever *nBm*. Arm *Bm* of link *3* moves in slider *4*, and arm *Bn* in slider *2* which turns about fixed axis *A*. When slider *1* moves along guides *q-q*, point *B* describes hyperbola *p-p* with the equation

$$y^2 \sin^2 \beta + xy \sin(\beta - \alpha) - y[e \sin \beta + d \sin(\beta + \alpha)] - x[d \sin \beta + e \sin(\beta - \alpha)] = 0$$

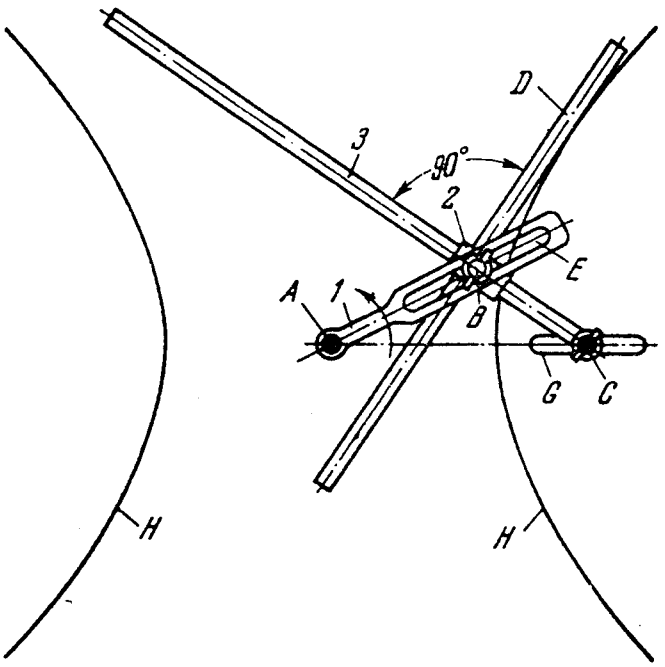
where $d$ and $e$ = constant dimensions of the mechanism
$\alpha$ and $\beta$ = constant angles complying with the condition $\alpha \neq \beta$.

If angle $\alpha = \beta$ then point *B* describes a parabola.

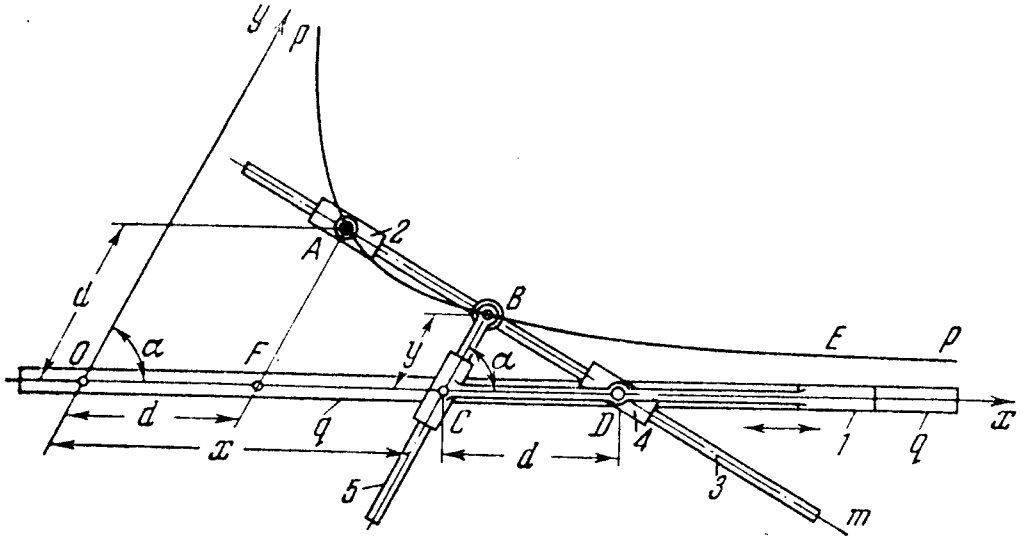



The mechanism is based on crossed-crank linkage *ABCD*. Added to this linkage is a double guiding element consisting of two sliders, *5* and *6*, connected together by turning pair *E*. The mechanism is intended for tracing hyperbolas. Pivots *A* and *D* are placed at the foci of the hyperbola. The tracing point is at the centre of pivot *E*. In the position shown, the mechanism traces the right branch $H_1$ of the hyperbola. To trace the left branch $H_2$ the mechanism should be turned through 180°. Hyperbolas of various sizes can be obtained by varying the lengths of links *1*, *2*, *3* and *4*. This is done by adjusting pivots *B*, *C* and *D* in slots *F*, *G*, *K* and *L* of links *1*, *2*, *3* and *4*.

| 1088 | ARTOBOLEVSKY LINK-GEAR ENVELOPING MECHANISM FOR HYPERBOLAS | LG Ge |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AC} > \overline{AB}$. Crank *1*, of length $\overline{AB}$, turns about fixed axis *A*. Sliding link *3* turns about fixed axis *C*. Slider *2*, moving along the axis of link *3*, carries rule *D*. When crank *1* turns about axis *A*, rule *D*, secured to slider *2*, envelops hyperbola *H*. Length $\overline{AB}$ of crank *1* is varied by adjusting pivot *B* in slot *E* of the crank. The distance between the vertices of the hyperbola is twice the length $\overline{AB}$. The centre of pivot *C* is placed at one focus of the hyperbola. Hyperbolas of the required size can be obtained by adjusting pivots *B* and *C* in slots *E* and *G*.

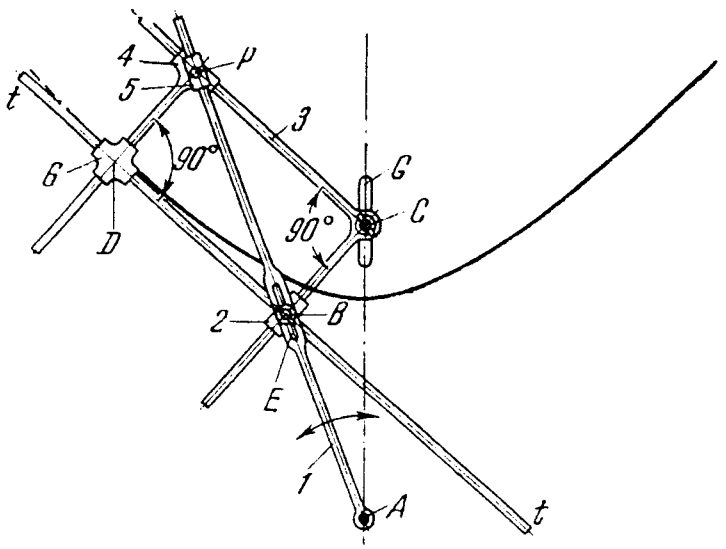



Slider *1*, moving along fixed guides *q-q*, is connected by turning pair *D* to slider *4* and by a sliding pair to link *5*. Link *5* is connected by turning pair *B* to link *3* which moves in sliders *4* and *2*. Slider *2* turns about fixed axis *A*. When slider *1* moves along guides *q-q*, point *B* describes equilateral hyperbola *p-p* with the equation

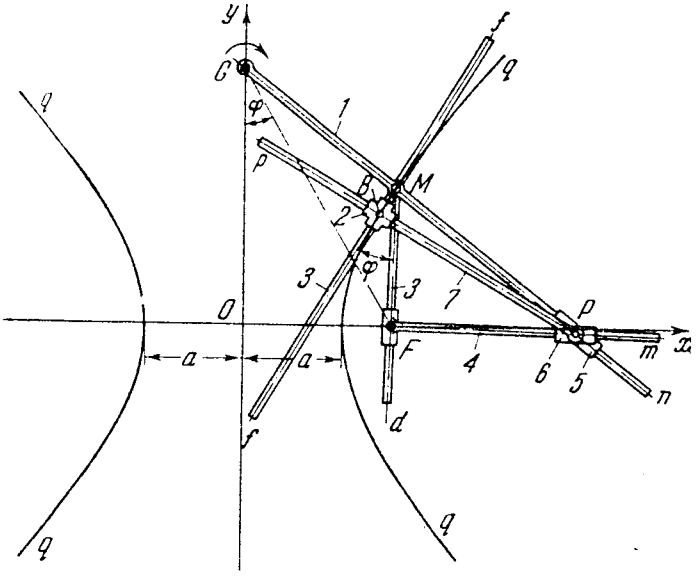
$$xy = d^2$$

where *d* is a constant dimension of the mechanism. Axes *Ox* and *Oy* are asymptotes of hyperbola *p-p*

| 1099 | ARTOBOLEVSKY LINK-GEAR TRACING AND ENVELOPING MECHANISM FOR HYPERBOLAS | LG Ge |
|---|---|---|




The mechanism is based on the four-bar link-gear linkage *ABC* for enveloping hyperbolas, with the addition of a double guiding element consisting of two sliders, *4* and *5*, connected together by turning pair *P*. Point *P* describes the space centrode of slider *2*. Sliders *2* and *4* are connected by sliding pairs to cross-shaped slider *6* which has guides perpendicular to each other. When crank *1* turns about fixed axis *A*, centre *D* of cross-shaped slider *6* describes a hyperbola, and rule *t-t*, secured rigidly to slider *2*, simultaneously envelops the hyperbola. Pivot *C* is placed at a focus of the hyperbola, and pivot *A* at its centre. Hyperbolas of the required dimensions can be obtained by adjusting pivots *B* and *C* along slots *E* and *G*.

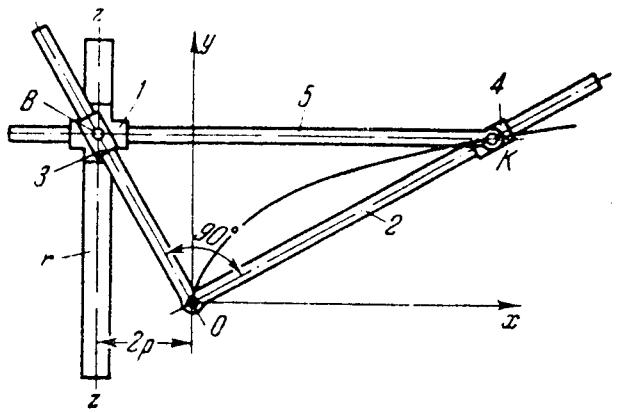



Link *1*, turning about fixed axis *G*, is connected by turning pair *M* to link *3* which has the form of a bent lever with the angle *dMf* equal to φ. Arm *Md* of link *3* slides in slider *4* which turns about fixed axis *F*. Arm *Mf* of link *3* moves in cross-shaped slider *2* which has guides perpendicular to each other. Sliders *6* and *5*, connected together by turning pair *P*, move along directions *Fm* and *Gn* of links *4* and *1*. Centre *F* is placed at one focus of a hyperbola and centre *G* on axis *Oy*, passing through centre *O* of the hyperbola, so that the distance $\overline{GO}$ equals

$$\overline{GO} = \frac{\overline{OF}}{\tan \varphi}.$$

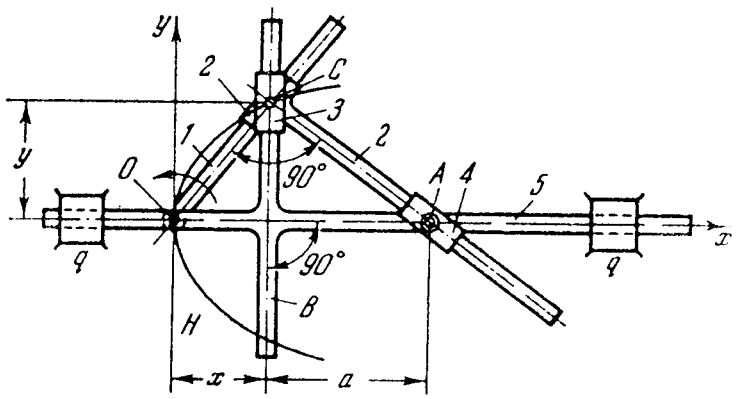
The length $\overline{GM}$ of link *1* is taken equal to $\overline{GM} = \frac{a}{\sin \varphi}$, where *a* is the transverse semiaxis of the hyperbola. Then, when link *1* turns about axis *G*, straight line *Mf* envelops hyperbola *q-q* and point *B* of slider *2*, at the intersection of lines *Pp* and *Mf*, describes hyperbola *q-q*.

| 1092 | ANTONOV LINK-GEAR PARABOLOGRAPH | LG Ge |
|---|---|---|

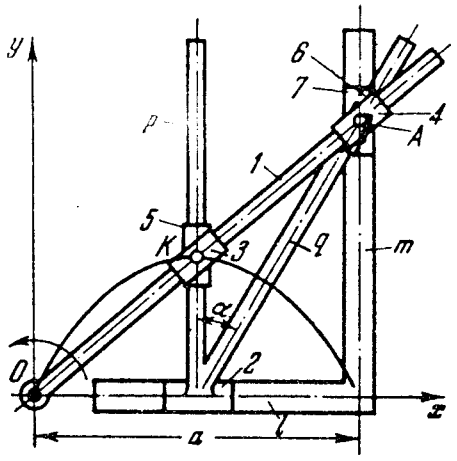



Link *2*, designed as a bent lever, turns about fixed axis *O*. One arm of link *2* moves in slider *4* and the other arm in slider *3*. Slider *4* is connected by turning pair *K* to link *5*, and slider *3* by turning pair *B* to cross-shaped slider *1* which has guides perpendicular to each other. Slider *1* moves along fixed guides *r*. Link *5* is connected by a sliding pair to slider *1*. When slider *1* moves along axis *z-z* of guides *r*, point *K* describes a parabola with the equation $y^2 = 2px$, where $2p$ is the distance from axis *y* to axis *z-z*.

| 1093 | LINK-GEAR PARABOLOGRAPH | LG Ge |
|---|---|---|



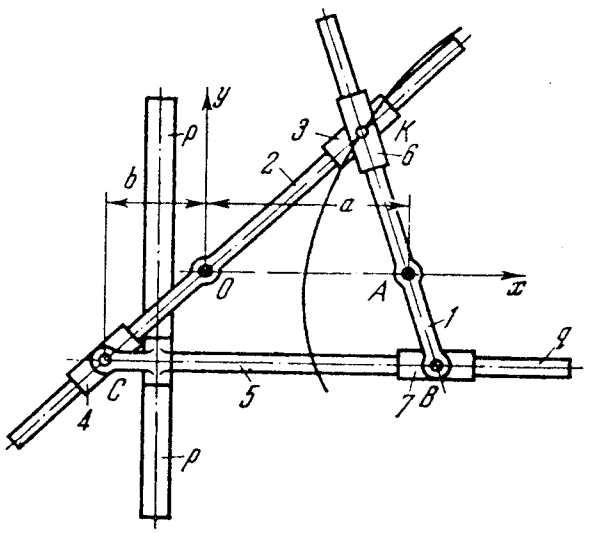

Sliding link *1* turns about fixed axis *O*. Slider *2*, connected by a sliding pair to slider *4*, moves along the axis of sliding link *1*. Slider *4* is connected by turning pair *A* to link *5* which reciprocates in fixed guides *q-q*. Link *5* is designed as a cross-shaped lever with one arm moving in slider *3*. Slider *3* is connected by turning pair *C* to slider *2*. When crank *1* turns about axis *O*, point *C* describes parabola *H* with the equation $y^2 = ax$, where *a* is a constant dimension of the mechanism.




Crank *1*, turning about fixed axis *O*, moves in sliders *3* and *4*. Slider *3* is connected by turning pair *K* to slider *5* which moves along extension *p* of slider *2*. Extension *q* of slider *2* moves in slider *6* which is connected by turning pair *A* to sliders *4* and *7*. Slider *7* moves along fixed guides *m* whose axis is perpendicular to the axis of fixed guides *l* along which slider *2* moves. When sliding link *1* turns about axis *O*, point *K* describes a parabola with the equation

$$y = \frac{x^2}{a \tan \alpha} + \frac{x}{\tan \alpha}$$

where $a$ = distance from axis $Oy$ to vertical guides $m$
$\alpha$ = angle between extensions $p$ and $q$.



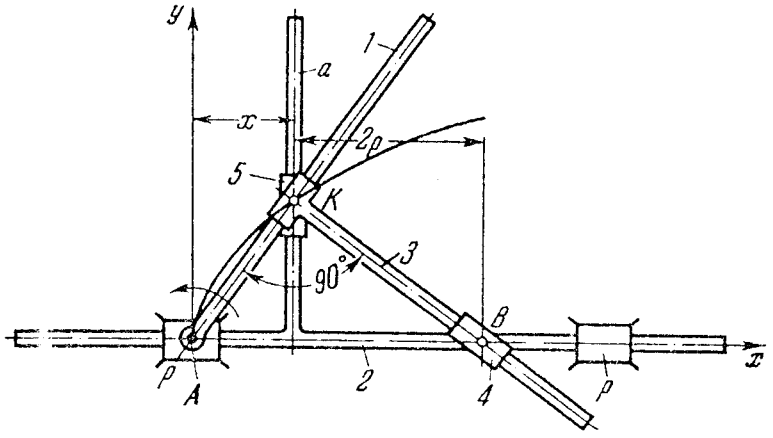

The lengths of the links comply with the condition: $\overline{AB} = b$. Link *2*, turning about fixed axis *O*, moves in sliders *3* and *4*. Slider *4* is connected by turning pair *C* to slider *5* which moves along fixed guides *p-p*. Link *1*, turning about fixed axis *A*, is connected by a sliding pair to slider *6* and by turning pair *B* to slider *7* which moves along extension *q* of slider *5*. Sliders *3* and *6* are connected together by turning pair *K*. When sliding link *1* turns about axis *A*, point *K* describes a portion of a parabola with the equation

$$y^2 + 2ax - a^2 = 0$$

where $a = \overline{OA}$.

## 1096 LEBEAU LINK-GEAR PARABOLOGRAPH

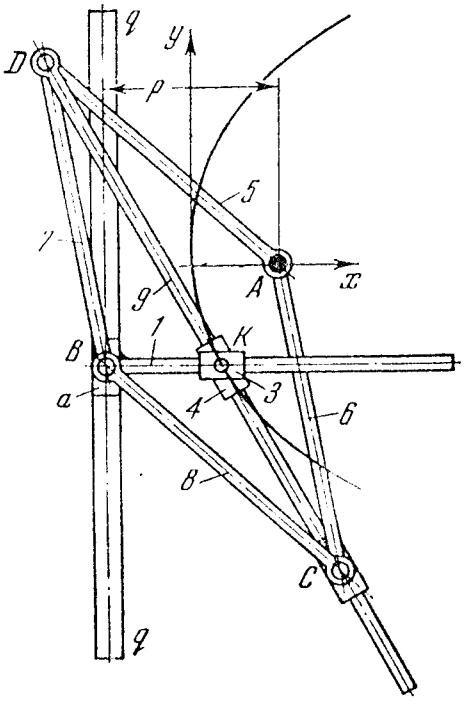
LG
Ge




Link *1*, turning about fixed axis *A*, is connected by a sliding pair to link *3* which slides in link *4*. Link *4* is connected by turning pair *B* to link *2* which slides in fixed guides *p-p*. Extension *a* of link *2* has its axis perpendicular to the axis of guides *p-p* in which link *2* slides. Extension *a* is connected by a sliding pair to slider *5*. Link *3* is connected by turning pair *K* to slider *5*. When link *1* turns about axis *A*, point *K* describes a parabola with the equation $y^2 = 2px$, where $2p$ is the distance from point *B* to the axis of extension *a* of link *2*.

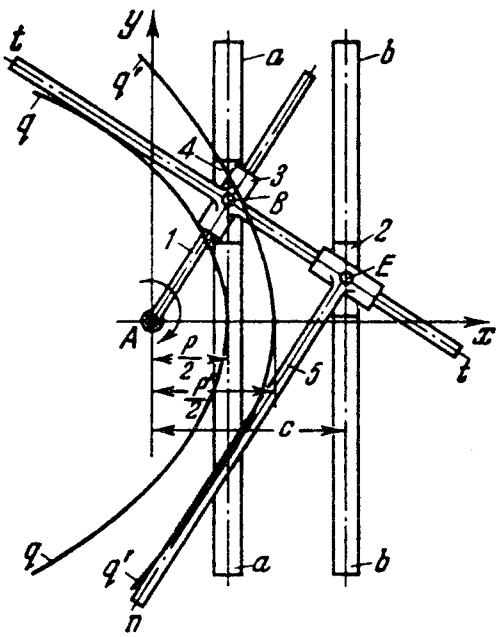
## 1097 EINDVARDTS LINK-GEAR PARABOLOGRAPH

LG
Ge



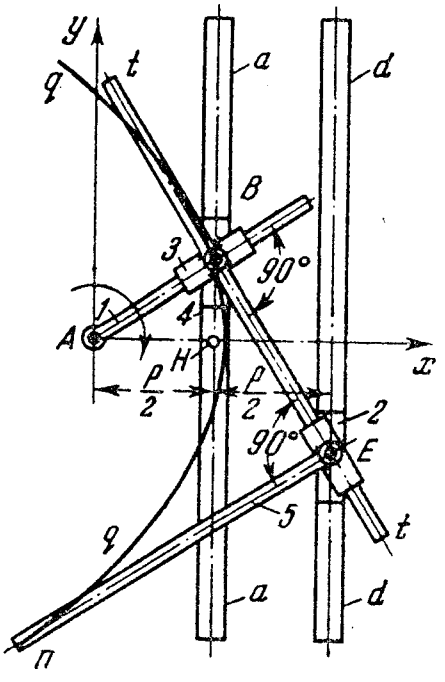

The lengths of the links comply with the conditions: $\overline{AD} = \overline{DB} = \overline{BC} = \overline{CA}$, i.e. figure *ADBC* is a rhombus linkage. Links *5* and *6* turn about fixed axis *A*. Links *7* and *8* are connected by turning pairs *B* to slider *a* of link *1* which moves along fixed guides *q-q*. Slider *3* is connected by turning pair *K* to slider *4* through which link *9* moves. Link *9* is diagonal *DC* of rhombus linkage *ADBC*. When slider *a* moves along guides *q-q*, point *K* describes a parabola with the equation $y^2 = 2px$, where *p* is the distance from point *A* to the axis of guides *q-q*.

| 1098 | ARTOBOLEVSKY LINK-GEAR PARABOLA ENVELOPMENT MECHANISM | LG Ge |
|---|---|---|



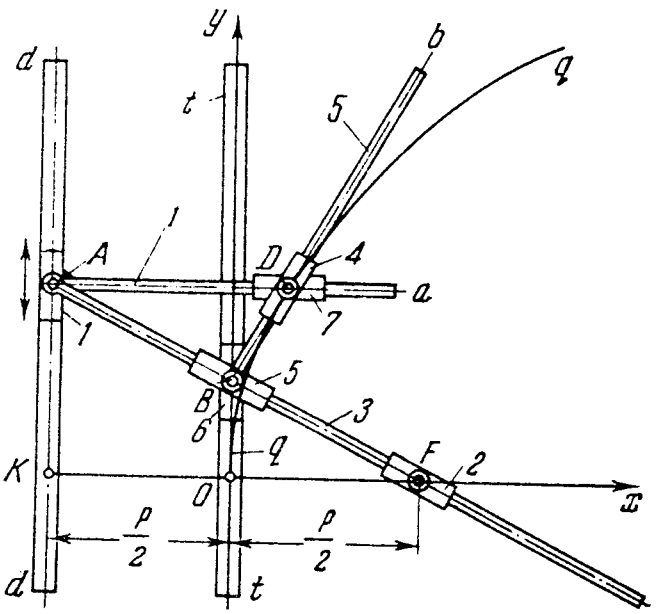

Link *1*, turning about fixed axis *A*, is connected by a sliding pair to link *3* which, in turn, is connected by turning pair *B* to slider *4*. Slider *4* moves along fixed guides *a-a* whose axis is parallel to axis *Ay*. Cross-piece *Bt* of link *3* is connected by a sliding pair to link *5*. Link *5* is connected by turning pair *E* to slider *2* which moves along fixed ways *b-b* whose axis is also parallel to axis *Ay*. Centre *A* is placed at the common focus of the parabolas to be enveloped, the axis of guides *a-a* is made to coincide with the directrix of parabola *q-q* and the axis of guides *b-b* is located at a distance from point *A* equal to $c = \frac{p + p'}{2}$, where $p$ and $p'$ are the distances from directrices to the focus of parabolas *q-q* and *q'-q'*. When link *1* turns about axis *A*, cross-pieces *Bt* and *En* of links *3* and *5* simultaneously envelop confocal parabolas *q-q* and *q'-q'*.

| 1099 | ARTOBOLEVSKY LINK-GEAR PARABOLA ENVELOPMENT MECHANISM | LG Ge |
|---|---|---|



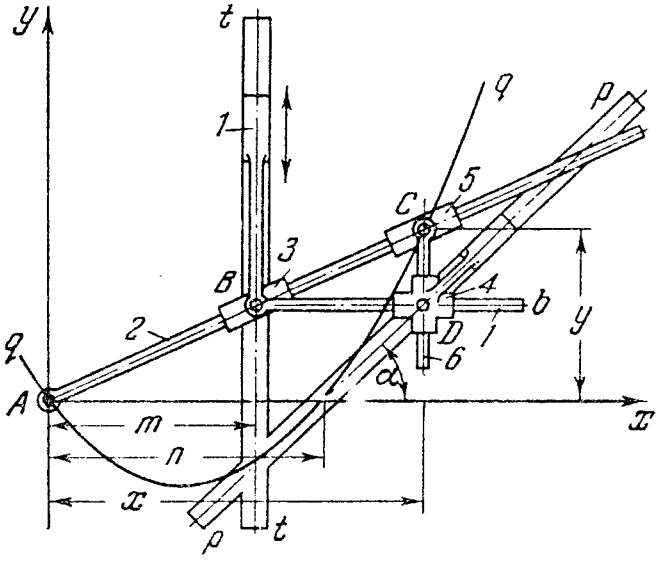

Link *1*, turning about fixed axis *A*, is connected by a sliding pair to link *3*. Link *3* is connected by turning pair *B* to slider *4* which moves along fixed guides *a-a* whose axis is parallel to axis *Ay*. Cross-piece *Bt* of link *3* is connected by a sliding pair to slider *5* which, in turn, is connected by turning pair *E* to slider *2*. Slider *2* moves along fixed guides *d-d* whose axis is also parallel to axis *Ay*. Centre *A* is placed at the focus of the parabola to be enveloped and the axis of guides *d-d* is made to coincide with the directrix of the parabola. When link *1* turns about axis *A*, cross-pieces *Bt* and *En* of links *3* and *5* simultaneously envelop parabola *q-q*.

| 1100 | ARTOBOLEVSKY LINK-GEAR PARABOLOGRAPH | LG<br>Ge |
|---|---|---|




Slider *1* moves along fixed guides *d-d* whose axis is parallel to axis *Oy*. Cross-piece *Aa* of slider *1* is connected by a sliding pair to slider *7*. Slider *6*, moving along fixed guides *t-t* whose axis coincides with axis *Oy*, is connected by turning pair *B* to slider *5*. Cross-piece *Bb* of slider *5* moves in slider *4* which is connected by turning pair *D* to slider *7*. Link *3* is connected by turning pair *A* to slider *1* and by sliding pairs to slider *5* and to slider *2* which turns about fixed axis *F*. Point *F* is placed at the focus of a parabola and the axis of guides *d-d* are made to coincide with the directrix of the parabola. Then, when slider *1* moves along guide *d-d*, point *D* describes parabola *q-q* with the equation $y^2 = 2px$, where $p$ is the distance from the focus of the parabola to its directrix.

| 1101 | ARTOBOLEVSKY LINK-GEAR PARABOLOGRAPH | LG Ge |
|---|---|---|




Slider *1* moves along fixed guides *t-t* whose axis is parallel to axis *Ay*. Slider *1* is connected by turning pair *B* to slider *3*. Cross-piece *Bb* of slider *1* moves in cross-shaped slider *4* which has guides perpendicular to each other. Slider *4* moves along fixed guides *p-p* whose axis makes the angle $\alpha$ with axis *Ax*. Slider *4* is connected by a sliding pair to link *6* which, in turn, is connected by turning pair *C* to slider *5*. Link *2*, turning about fixed axis *A*, is connected by sliding pairs to sliders *3* and *5*. When slider *1* moves along guides *t-t*, point *C* describes parabola *q-q* with the equation

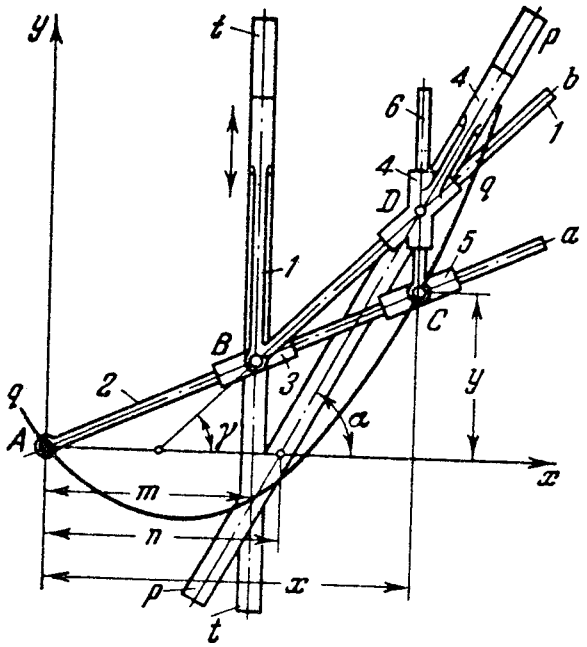
$$ex^2 + 2fx + 2gy = 0$$

where $e = \tan\alpha$

$$f = -\frac{n \tan\alpha}{2}$$

$$g = -\frac{m}{2}$$

*m* and *n* = constant dimensions of the mechanism.




Slider *1* moves along fixed guides *t-t* whose axis is parallel to axis *Ay*. Slider *1* is connected by turning pair *B* to slider *3*. Cross-piece *Bb* of slider *1* moves in X-shaped slider *4* which has guides making the angle $90° - \gamma$ with each other. Slider *4* moves along fixed guides *p-p*, whose axis makes angle $\alpha$ with axis *Ax*, and is connected by a sliding pair to link *6*. Link *6* is connected by turning pair *C* to slider *5*. Link *2*, turning about fixed axis *A*, is connected by sliding pairs to sliders *3* and *5*. When slider *1* moves along guides *t-t*, point *C* describes parabola *q-q* with the equation

$$ex^2 + 2fx + 2gy = 0$$

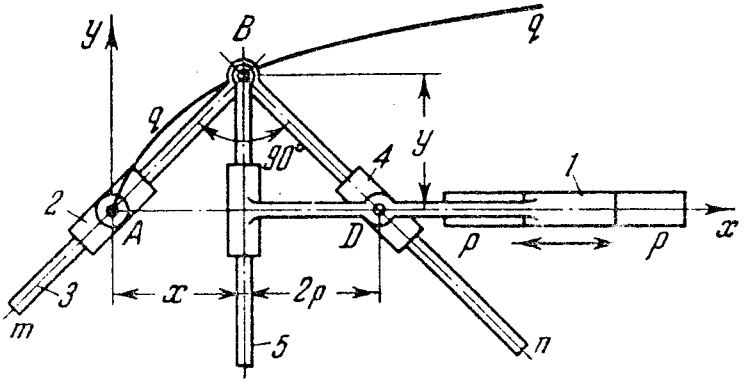
where $e = \tan\alpha - \tan\gamma$

$$f = \frac{m\tan\gamma - n\tan\alpha}{2}$$

$$g = -\frac{m}{2}$$

*m* and *n* = constant dimensions of the mechanism.

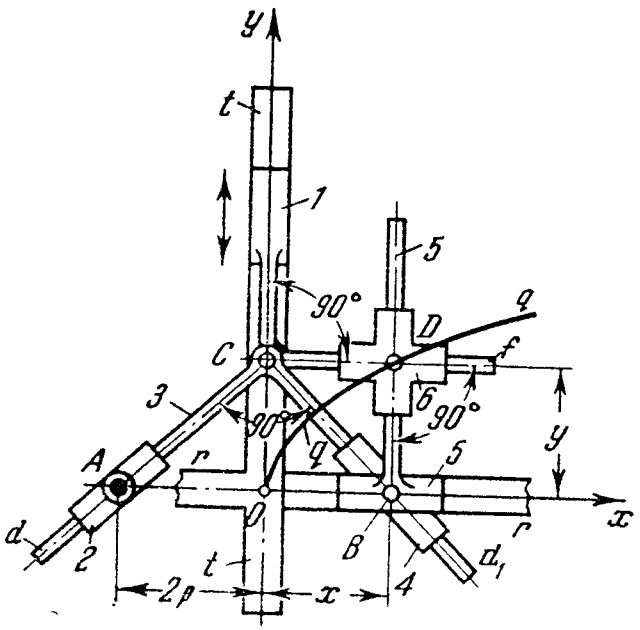
| 1103 | LEBEAU LINK-GEAR PARABOLOGRAPH | LG Ge |
|---|---|---|




Slider *1* moves along fixed guides *p-p* whose axis coincides with axis *Ax*. Slider *1* is connected by a sliding pair to link *5* which, in turn, is connected by turning pair *B* to link *3* having the form of a bent lever with the angle *nBm* equal to 90°. Arm *Bn* of link *3* moves in slider *4* which is connected by turning pair *D* to slider *1*. Arm *Bm* of link *3* moves in slider *2* which turns about fixed axis *A*. When slider *1* moves along guides *p-p*, point *B* describes parabola *q-q* with the equation

$$y^2 = 2px$$

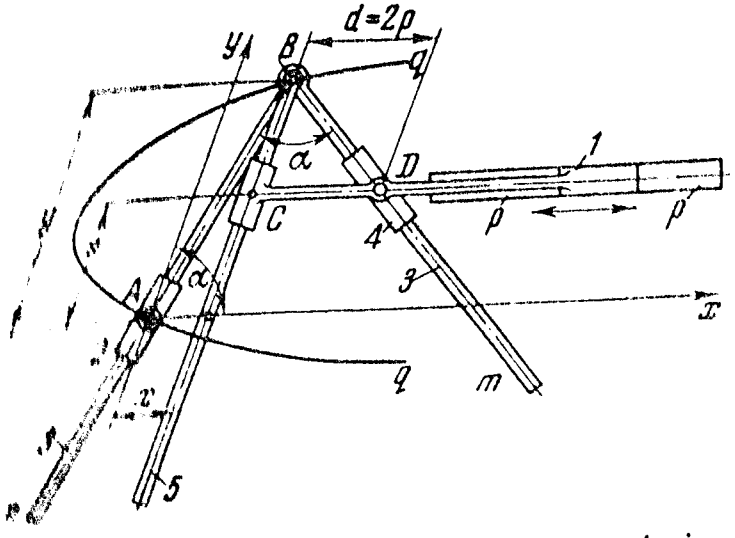
where *p* is the distance from the focus of the parabola to its directrix.




Slider *1* moves along fixed guides *t-t* whose axis coincides with axis *Oy*. Slider *1* is connected by turning pair *C* to link *3* having the form of a bent lever with the angle $dCd_1$ equal to 90°. Arm *Cd* of link *3* moves in slider *2* which turns about fixed axis *A*. Arm $Cd_1$ moves in slider *4*. Cross-shaped slider *6* has guides perpendicular to each other and is connected by sliding pairs to cross-piece *Cf* of slider *1* and to link *5*. Link *5* slides along fixed guides *r-r* whose axis coincides with axis *Ox*. When slider *1* moves along guides *t-t*, point *D* describes parabola *q-q* with the equation

$$y^2 = 2px$$

where $p$ is the distance from the focus of the parabola to its directrix.




Slider *1* moves along fixed guides *p-p* whose axis is parallel to axis *Ax*. Slider *1* is connected by a sliding pair to link *5*. Link *5* is connected by turning pair *B* to link *3* having the form of a bent lever with the angle *nBm* equal to $\alpha$, where $\alpha$ is the angle between the coordinate axes *Ax* and *Ay*. Arm *Bm* of link *3* moves in slider *4* which is connected by turning pair *D* to slider *1*. Arm *Bn* of link *3* moves in slider *2* which turns about fixed axis *A*. When slider *1* moves along guides *p-p*, point *B* describes parabola *q-q* with the equation

$$fy^2 + 2gx + 2hy = 0$$

where $f = \sin\alpha$

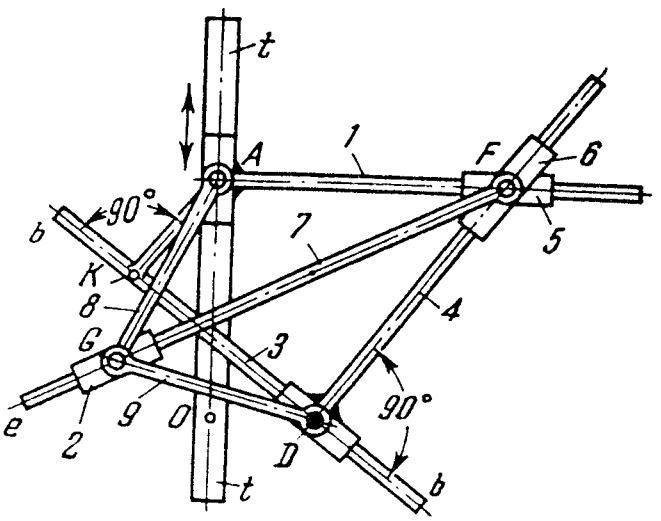
$g = \frac{d}{2} = -p$

$h = \frac{e + 2d\cos\alpha}{2}$

$e$ — distance along *Ay* axis from axis *Ax* to the axis of guides *p-p*

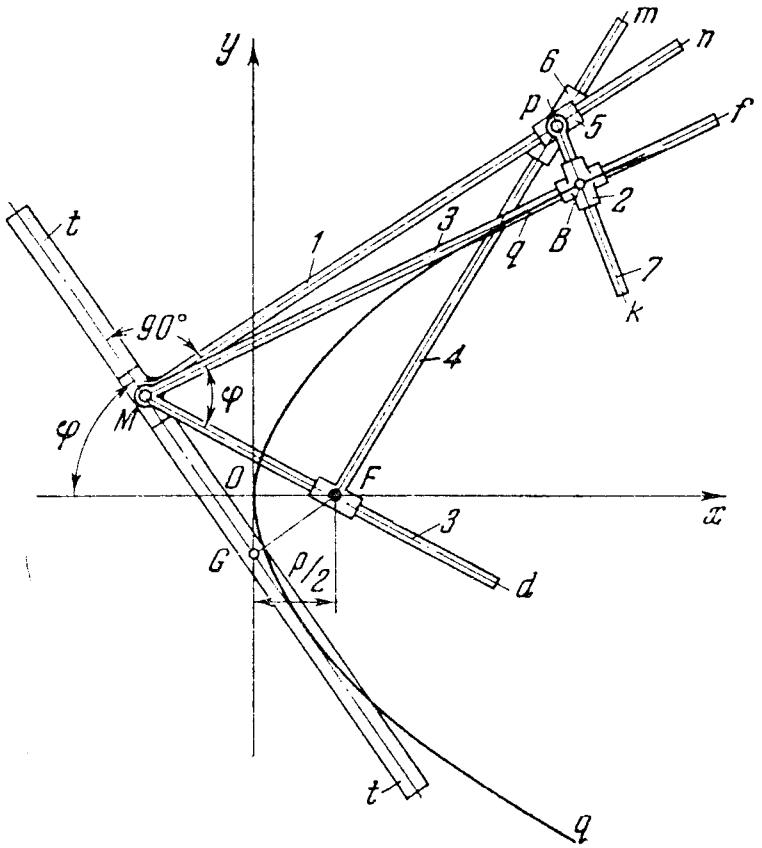
$p$ — distance from the focus of the parabola to its directrix.

| 1106 | LINK-GEAR TRACING AND ENVELOPING MECHANISM FOR PARABOLAS | LG Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AF} = \overline{DF}$ and $\overline{AK} = \overline{DO}$, where $\overline{DO}$ is the distance from the focus of the parabola to its directrix. Slider *1* moves along fixed guides *t-t*, and is connected by a sliding pair to slider *5* and by turning pairs *A* to links *3* and *8*. Slider *4*, turning about fixed axis *D*, is connected by a sliding pair to slider *6* and by another sliding pair to link *3*. Sliders *5* and *6* are connected together by turning pair *F*. Link *9*, turning about axis *D*, is connected by turning pairs *G* to link *8* and slider *2*. Slider *2* moves along link *7* which is connected by turning pair *F* to sliders *5* and *6*. Point *D* is placed at the focus of a parabola and the axis of guides *t-t* is made to coincide with the directrix of the parabola. Then, when slider *1* moves along guides *t-t*, point *F* describes a parabola and straight line *Fe* envelops this parabola.

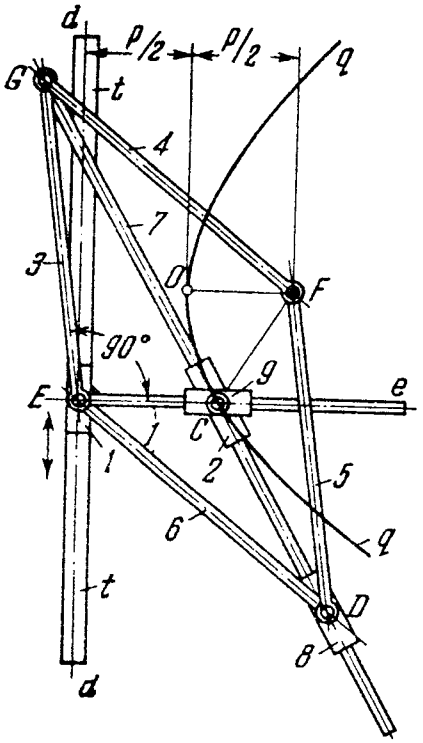
| 1107 | ARTOBOLEVSKY LINK-GEAR TRACING AND ENVELOPING MECHANISM FOR PARABOLAS | LG Ge |
|---|---|---|




Slider *1* moves along fixed guides *t-t* whose axis passes through point *G* and makes the angle φ with axis *Ox*. Slider *1* is connected by turning pair *M* to link *3* having the form of a bent lever with the angle *dMf* equal to φ. Arm *Md* of link *3* moves in slider *4* which turns about fixed axis *F*. Arm *Mf* of link *3* moves in cross-shaped slider *2* which has guides perpendicular to each other. Sliders *5* and *6*, connected together by turning pair *P*, move along cross-pieces *Mn* and *Fm* of sliders *1* and *4*. Point *F* is placed at the focus of a parabola and point *G* is located on axis *Oy* (passing through vertex *O* of the parabola) at the distance $\overline{GO}$ equal to

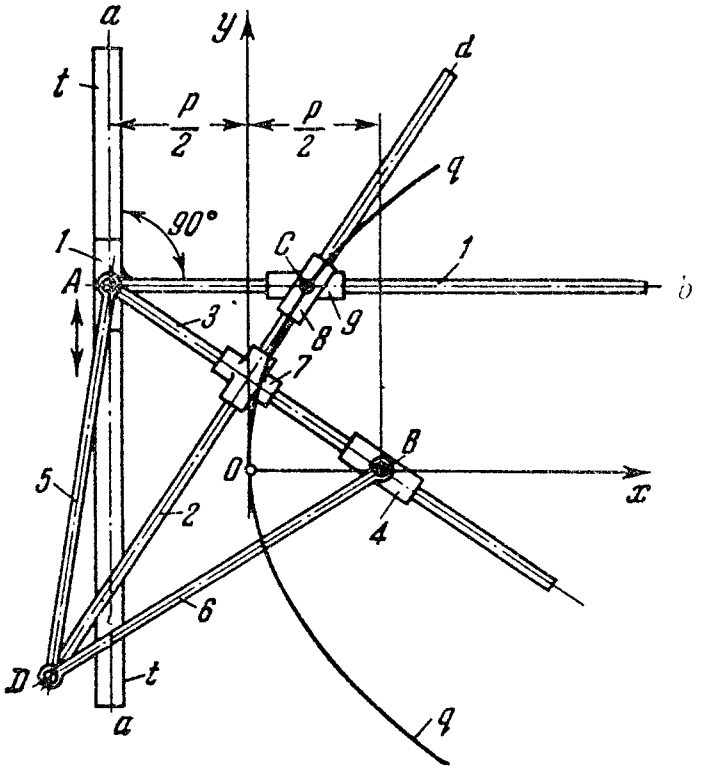
$$\overline{GO} = \frac{\overline{OF}}{\tan\varphi} = \frac{p}{2\tan\varphi}$$

where *p* is the given distance between the focus of the parabola and its directrix. Then, when slider *1* moves along guides *t-t*, straight line *Mf* envelops parabola *q-q* and point *B* of slider *2*, at the intersection of axes *Pk* and *Mf*, describes parabola *q-q*.



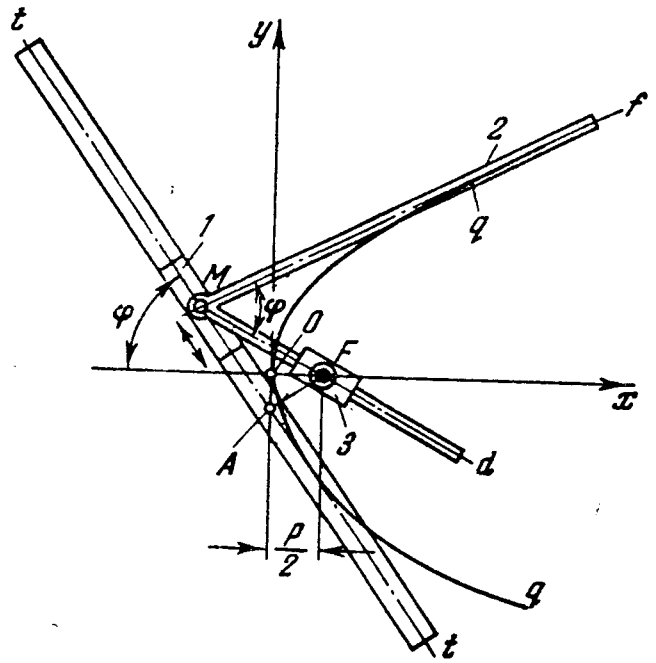

The length of the links comply with the conditions: $\overline{EG} = \overline{GF} = \overline{FD} = \overline{DE}$. Figure *GFDE* is a rhombus linkage. Slider *1* moves along fixed guides *t-t* and is connected by turning pairs *E* to links *3* and *6*. Link *7*, connected by turning pairs *G* to links *3* and *4*, moves in sliders *2* and *8*. Slider *2* is connected by turning pair *C* to slider *9*, and slider *8* is connected by turning pairs *D* to links *5* and *6*. Slider *9* moves along cross-piece *Ee* of slider *1*. Point *F* is placed at the focus of a parabola and axis *d-d* of guides *t-t* is made to coincide with its directrix. Then, when slider *1* moves along guides *t-t*, point *C* describes parabola *q-q* with the distance *p* between the focus and directrix. At the same time, straight line *DG* envelops the parabola.

| 1109 | ARTOBOLEVSKY LINK-GEAR TRACING AND ENVELOPING MECHANISM FOR PARABOLAS | LG Ge |
|---|---|---|




Slider *1* moves along fixed guides *t-t* and has cross-piece *Ab* connected by a sliding pair to slider *9*. Slider *1* is connected by turning pairs *A* to links *3* and *5*. Link *3* moves in cross-shaped slider *7* which has guides perpendicular to each other. Link *2*, connected by turning pairs *D* to links *5* and *6*, moves in sliders *7* and *8*. Sliders *8* and *9* are connected together by turning pair *C*. Link *6* turns about fixed axis *B*. Link *3* moves in slider *4* which turns about axis *B*. Point *B* is placed at the focus of a parabola, axis *a-a* of guides *t-t* is made to coincide with the directrix of the parabola, and the lengths of links *5* and *6* are taken equal to each other. Then, when slider *1* moves along guides *t-t*, point *C* describes parabola *q-q* with the distance *p* between the focus and directrix. At the same time, straight line *Dd* envelops the parabola.

| 1110 | ARTOBOLEVSKY LINK-GEAR PARABOLA ENVELOPMENT MECHANISM | LG Ge |
|---|---|---|

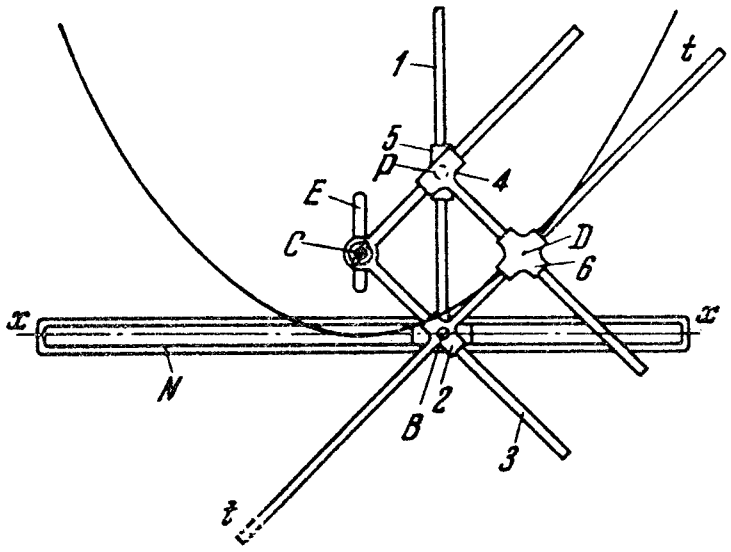



Slider *1* moves along fixed guides *t-t* whose axis passes through point *A* making the angle φ with axis *Ox*. Slider *1* is connected by turning pair *M* to link *2* having the form of a bent lever with the angle *dMf* equal to φ. Arm *Md* of link *2* moves in slider *3* which turns about fixed axis *F*. Point *F* is placed at the focus of a parabola and point *A* is located on axis *Oy* (passing through vertex *O* of the parabola) at the distance $\overline{AO}$ equal to

$$\overline{AO} = \frac{\overline{OF}}{\tan\varphi} = \frac{p}{2\tan\varphi}$$

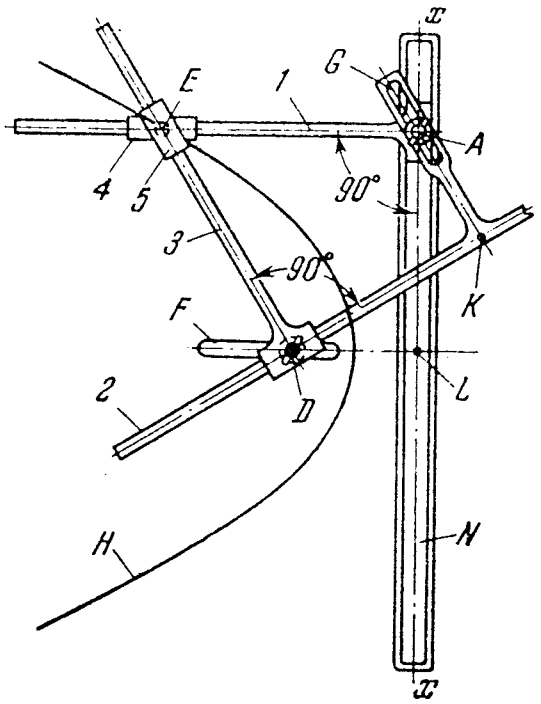
where *p* is the given distance between the focus of the parabola and its directrix. Then, when slider *1* moves along guides *t-t*, straight line *Mf* envelops parabola *q-q*.

| 1111 | ARTOBOLEVSKY LINK-GEAR TRACING AND ENVELOPING MECHANISM FOR PARABOLAS | LG Ge |
|---|---|---|



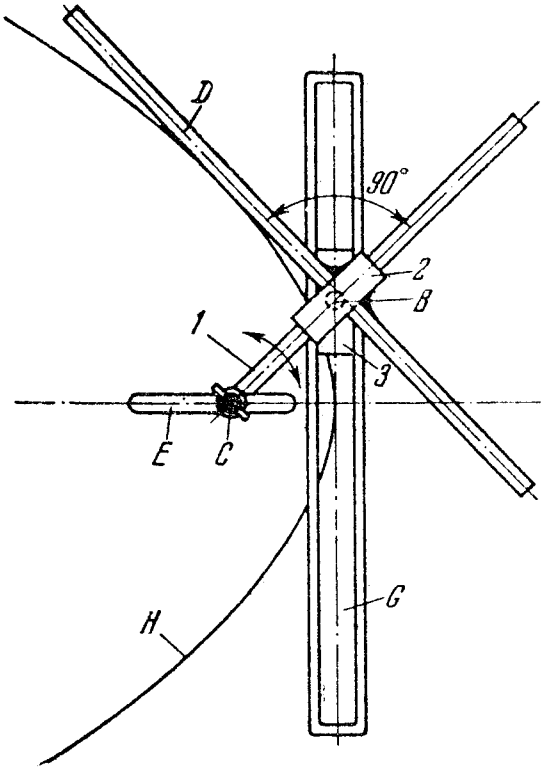

The mechanism is based on the four-bar link-gear linkage *BCD* for enveloping parabolas with the addition of a double guiding element consisting of two sliders, *4* and *5*, connected together by turning pair *P*. Point *P* describes the space centrode of slider *2*. Sliders *2* and *4* are connected by sliding pairs to cross-shaped slider *6* which has guides perpendicular to each other. When slider *1* moves along axis *x-x* of fixed guides *N*, point *D* of cross-shaped slider *6* describes a parabola and rule *t-t*, secured rigidly to slider *2*, envelops the parabola. Point *C* is placed at the focus of the parabola. Parabolas of various sizes can be obtained by adjusting pivot *C* along slot *E*.

| 1112 | ARTOBOLEVSKY LINK-GEAR PARABOLOGRAPH | LG<br>Ge |
|---|---|---|



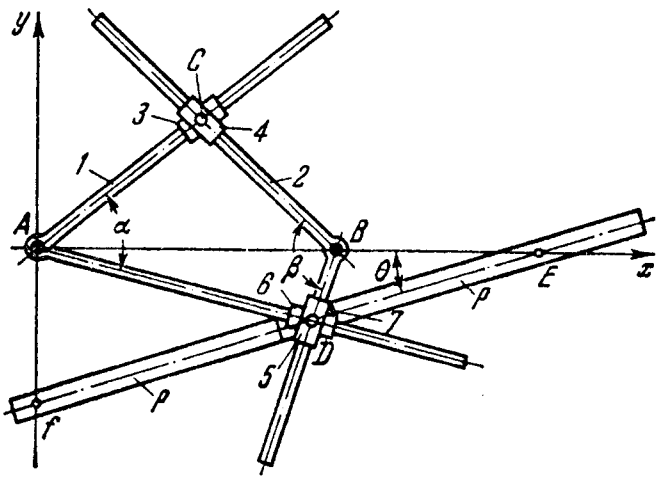

The mechanism is based on a four-bar linkage consisting of slider *1*, moving along fixed guides *N*, bent lever *2*, connected by turning pair *A* to slider *1*, and slider *3*, turning about fixed axis *D*. One arm of bent lever *2* moves in slider *3*. Added to this linkage is a double guiding element consisting of two sliders *5* and *4* connected together by turning pair *E*. When slider *1* moves along axis *x-x* of guides *N*, the centre of pivot *E* describes parabola *H*. Fixed pivot *D* is placed at the focus of the parabola, axis *x-x* coincides with the directrix and distances $\overline{AK}$ and $\overline{DL}$ are equal. Parabolas of various sizes can be obtained by adjusting fixed pivot *D* along slot *F* of the base and movable pivot *A* along slot *G* of link *2*.

| 1113 | ARTOBOLEVSKY LINK-GEAR PARABOLA ENVELOPMENT MECHANISM | LG Ge |
|---|---|---|




Sliding link *1* turns about fixed axis *C*. Slider *2*, moving along link *1*, carries rule *D*. Slider *3*, moving along fixed guides *G*, is connected by turning pair *B* to slider *2*. When link *1* rotates about axis *C*, rule *D*, rigidly secured to slider *2*, envelops parabola *H*. Point *C* is placed at the focus of the parabola and the axis of guides *G* passes through its vertex. Parabolas of various sizes can be obtained by adjusting pivot *C* along slot *E*.

| 1114 | BOGUSLAVSKY LINK-GEAR CONICOGRAPH MECHANISM | LG Ge |
|---|---|---|




Bent levers *1* and *2*, turning about fixed axes *A* and *B*, are connected by sliding pairs to sliders *3* and *6*, and *4* and *5*. Slider *7* moves along fixed guides *p-p*. When slider *7* moves along guides *p-p*, point *C* describes a conic section with the equation

$$gx^2 + 2hxy + jy^2 + 2mx + 2ny + l = 0$$

where $g = k \tan\alpha (\tan\theta - \tan\beta) + \tan\alpha + \tan\beta$

$$2h = k (\tan\beta - \tan\alpha - \tan\alpha \tan\beta \tan\theta - \tan\theta)$$

$$j = k (1 + \tan\beta \tan\theta) + \tan\alpha + \tan\beta$$

$$2m = j (k \tan\alpha \tan\beta - k \tan\alpha \tan\theta - \tan\beta - \tan\alpha)$$

$$2n = j (1 - k \tan\beta + k \tan\theta - \tan\alpha \tan\beta)$$

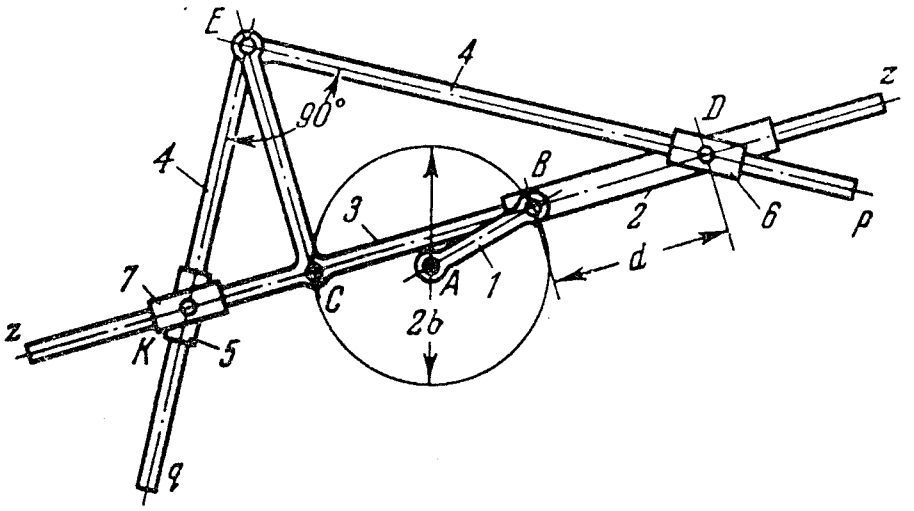
$$j = \overline{AB}$$

$$k = \frac{\overline{AB}\,(\overline{AB} + \overline{BE})}{\overline{BE} \times \overline{Af}}$$

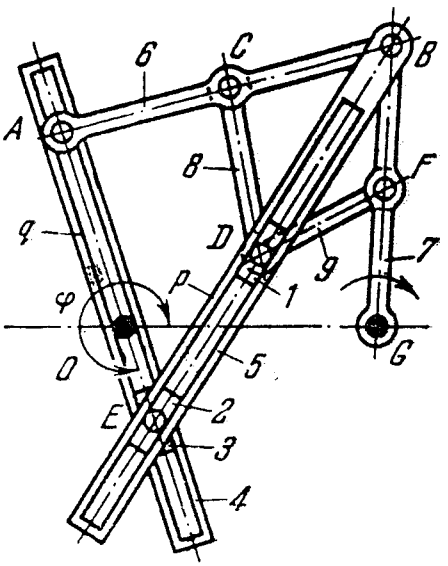
$$l = 0.$$

The mechanism is set up for tracing various conic sections by changing angles $\alpha$ and $\beta$, and the coefficient $k$.

| 1115 | CRAWFORD LINK-GEAR CONICOGRAPH | LG<br>Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AB} = \overline{AC} = b$ and $\overline{BD} = d$. Crank *1*, turning about fixed axis *A*, is connected by turning pair *B* to slider *2* which moves along cross-piece *z-z* of T-shaped link *3*. Link *3* turns about fixed axis *C*. Bent link *4* is connected by turning pair *E* to link *3*. Arm *Eq* of link *4* moves in slider *5*, and arm *Ep* in slider *6*, which is connected by turning pair *D* to slider *2*. Slider *5* is connected by turning pair *K* to slider *7* which moves along cross-piece *z-z* of link *3*. When crank *1* rotates about axis *A*, point *K* describes a conic section which is an ellipse when $2b/d < 1$, a parabola when $2b/d = 1$ and a hyperbola when $2b/d > 1$.




The lengths of the links comply with the conditions: $\overline{DC}^2 + \overline{BF}^2 = \overline{CB}^2 + \overline{DF}^2$ and $\overline{AB} : \overline{CB} = \overline{BG} : \overline{BF}$. The mechanism is based on four-bar linkage $OABG$. Link *5* is connected by turning pair $B$ to links *6* and *7*, and by a sliding pair to slider *1* which moves along slot $p$ of link *5*. Slider *1* is connected by turning pairs $D$ to links *8* and *9* which, in turn, are connected by turning pairs $C$ and $F$ to links *6* and *7*. Owing to the specified lengths of the links, the axis of slot $p$ of link *5* is always perpendicular to diagonal $AG$ of four-bar linkage $OABG$. Sliders *2* and *3*, connected together by turning pair $E$, move along slots $p$ and $q$ of links *5* and *4*. Point $E$ describes a conic section with the polar equation

$$\rho = \frac{p}{1 + e\cos\varphi}$$

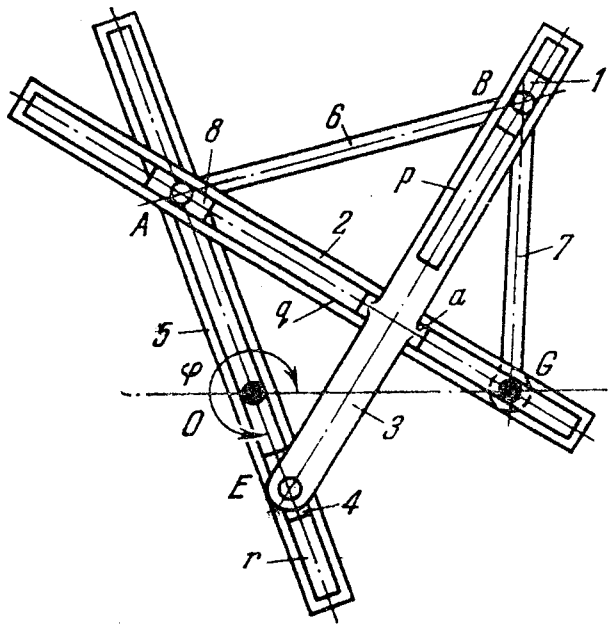
where $\rho = \overline{OE}$

$$p = \frac{\overline{OG}^2 + \overline{AB}^2 - \overline{OA}^2 - \overline{GB}^2}{2\overline{OA}}$$

$$e = \frac{\overline{OG}}{\overline{OA}}.$$

Point $E$ describes an ellipse when $e < 1$, a parabola when $e = 1$ and a hyperbola when $e > 1$. The axis of sliding slot $p$ of link *5* is always tangent to the traced conic section. The mechanism is set up by adjusting pivot $A$ along slot $q$ and clamping it in the required position.

| 1117 | KAMINSKY LINK-GEAR CONICOGRAPH | LG Ge |
|---|---|---|




The mechanism is based on four-bar linkage $OABG$. Slider *1*, connected by turning pairs $B$ to links *6* and *7*, moves along slot $p$ of link *3*. Link *3* is rigidly secured to slider $a$ whose axis of sliding is perpendicular to slot $p$. Slider $a$ of link *3* moves along slot $q$ of link *2* which turns about fixed axis $G$. Link *2* is connected by a sliding pair to slider *8*. Slider *8* is connected by turning pair $A$ to link *5* which turns about fixed axis $O$. Link *3* is connected by turning pair $E$ to slider *4* which moves along slot $r$ of link *5*. Point $E$ describes a conic section with the equation

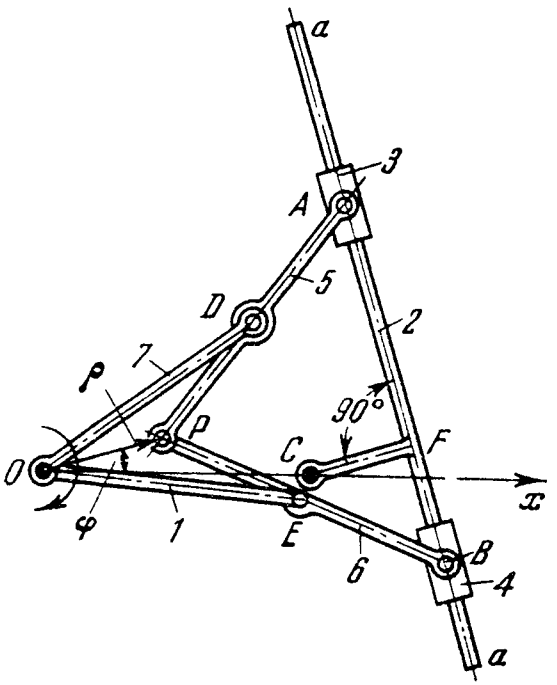
$$\rho = \frac{p}{1 + e\cos\varphi}$$

where $\rho = \overline{OE}$

$$p = \frac{\overline{OG}^2 + \overline{AB}^2 - \overline{OA}^2 - \overline{GB}^2}{2\overline{OA}}$$

$$e = \frac{\overline{OG}}{\overline{OA}}.$$

Point $E$ describes an ellipse when $e < 1$, a parabola when $e = 1$ and a hyperbola when $e > 1$. The axis of guiding slot $p$ of link *3* is always tangent to the traced conic section. The mechanism is set up for tracing various conic sections by changing length $\overline{OA}$ of link *5*. This is done by adjusting pivot $A$ along slot $r$ and clamping it in the required position.




The lengths of the links comply with the conditions: $\overline{PD} = \overline{DA} = \overline{PE} = \overline{EB} = c$, $\overline{PA} = \overline{PB} = 2c$ and $\overline{OD} = \overline{OE} = b$. Figure $ODPE$ is a rhomboid linkage. Links *1* and *7*, turning about fixed axis *O*, are connected by turning pairs *E* and *D* to links *6* and *5*. Links *5* and *6* are connected together by turning pair *P*, and are connected by turning pairs *A* and *B* to sliders *3* and *4* which move along cross-piece *a-a* of T-shaped link *2*. Link *2* turns about fixed axis *C*. Point *P* describes a conic section with the equation

$$\rho = \frac{p}{1 + e\cos\varphi}$$

where $\rho = \overline{OP}$

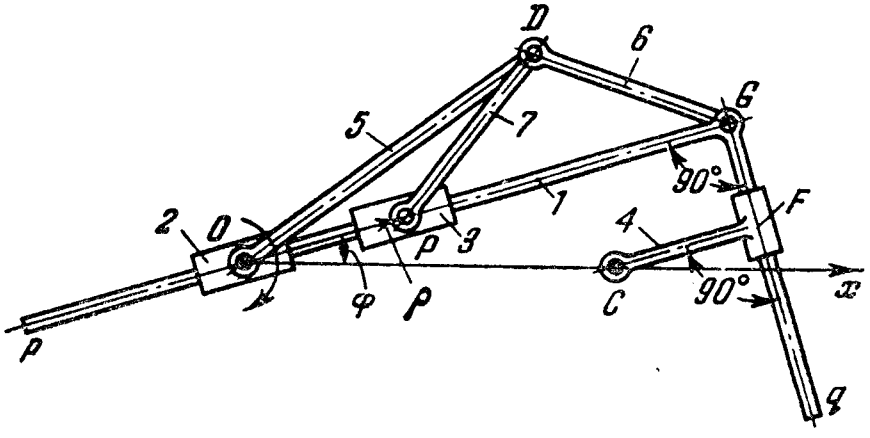
$$p = \frac{b^2 - c^2}{\overline{OC}}$$

$$e = \frac{\overline{OC}}{\overline{CF}}$$

$\varphi$ = polar angle between vector $\rho$ and the polar axis $Ox$.

Point *P* describes an ellipse when $e < 1$, a parabola when $e = 1$ and a hyperbola when $e > 1$.

| 1119 | ARTOBOLEVSKY LINK-GEAR CONICOGRAPH | LG<br>Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{DP} = \overline{DG}$ and $\overline{OP} \times \overline{OG} = \overline{OD}^2 - \overline{DG}^2 = \text{const}$. Link *4* turns about fixed axis *C*. Link *1* has the form of a bent lever. Arm *Gq* of link *1* slides in guide *F* of link *4*, and arm *Gp* moves in sliders *3* and *2*. Slider *2* turns about fixed axis *O*. Link *5* is connected by turning pairs *O* and *D* to slider *2* and to links *6* and *7*. Link *6* is connected by turning pair *G* to link *1*, and link *7* by turning pair *P* to slider *3*. When slider *2* turns about axis *O*, point *P* describes a conic section with the equation

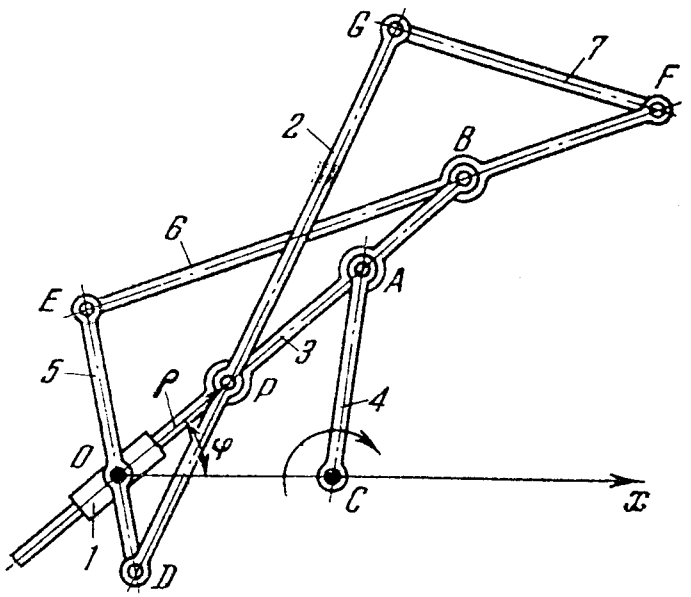
$$\rho = \frac{p}{1 + e\cos\varphi}$$

where $\rho = \overline{OP}$

$$p = \frac{\overline{OD}^2 - \overline{DG}^2}{\overline{CF}}$$

$$e = \frac{\overline{OC}}{\overline{CF}}$$

$\varphi$ = polar angle between vector $\rho$ and the polar axis *Ox*. Point *P* describes an ellipse when $e < 1$, a parabola when $e = 1$ and a hyperbola when $e > 1$.




The lengths of the links comply with the conditions: $\overline{DE} = \overline{GF}$, $\overline{DG} = \overline{EF}$, $\overline{AC} = \overline{OC}$, $\overline{OD} : \overline{OE} = \overline{DP} : \overline{EB}$ and $\overline{OP} \times \overline{OB} = (\overline{DP} \times \overline{EB}) - (\overline{OD} \times \overline{OE}) = \text{const}$. Figure *DEFG* is a crossed-crank linkage. Slider *1* turns about fixed axis *O*. Link *3*, moving in slider *1*, is connected by turning pairs *P*, *A* and *B* to links *2*, *4* and *6*. Link *2* is connected by turning pairs *D* and *G* to links *5* and *7*. Link *6* is connected by turning pair *F* to link *7* and by turning pair *E* to link *5*, which turns about fixed axis *O*. When link *4* turns about fixed axis *C*, point *P* describes a conic section with the equation

$$\rho = \frac{p}{1 + e\cos\varphi}$$

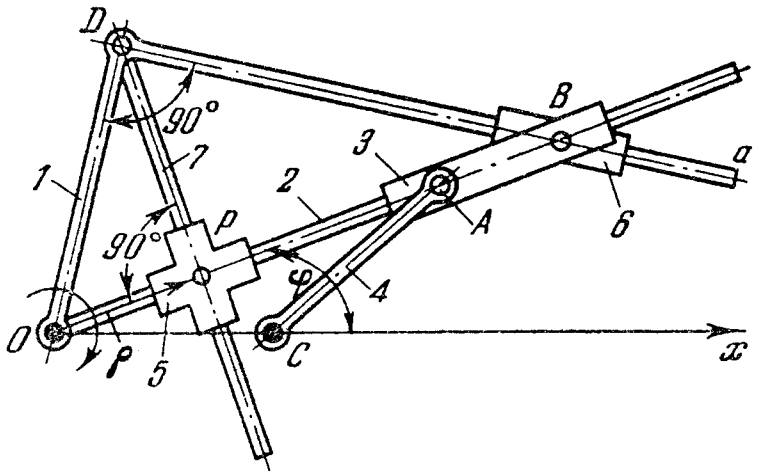
where $\rho = \overline{OP}$

$$p = \frac{(\overline{DP} \times \overline{EB}) - (\overline{OD} \times \overline{OE})}{\overline{AB}}$$

$$e = \frac{2\overline{AC}}{\overline{AB}}$$

$\varphi$ = polar angle between vector $\rho$ and the polar axis *Ox*.

Point *P* describes an ellipse when $e < 1$, a parabola when $e = 1$ and a hyperbola when $e > 1$.




The lengths of the links comply with the conditions: $\overline{AC} = \overline{OC}$ and $\overline{OP} \times \overline{OB} = \overline{OD}^2$. Link *1*, having the form of a bent lever, turns about fixed axis *O*. Arm *Da* of link *1* moves in slider *6*. Link *7*, connected by turning pair *D* to link *1*, moves in cross-shaped slider *5* which has guides perpendicular to each other. Link *2*, turning about axis *O*, moves in sliders *5* and *3*. Link *3* is connected by turning pair *B* to slider *6* and by turning pair *A* to link *4* which turns about fixed axis *C*. When link *1* turns about axis *O*, point *P* describes a conic section with the equation

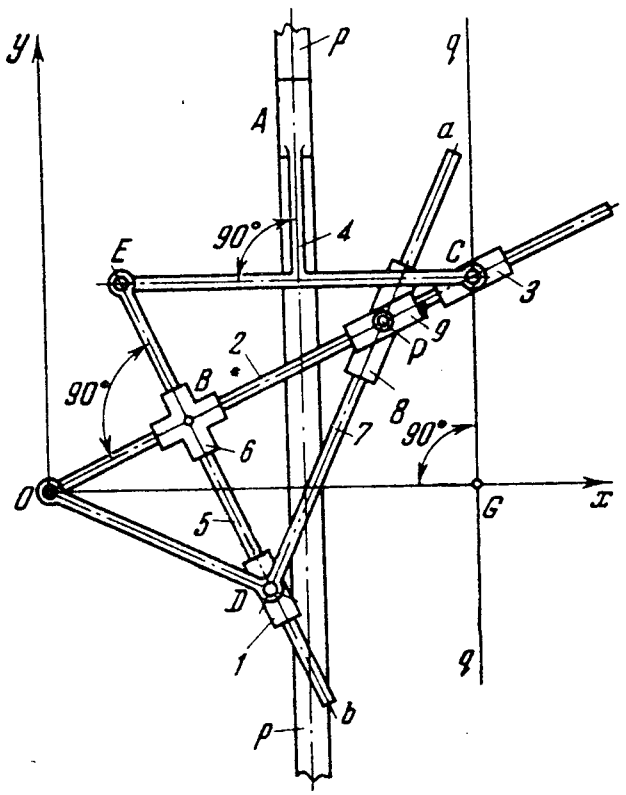
$$\rho = \frac{p}{1 + e\cos\varphi}$$

where $\rho = \overline{OP}$

$$p = \frac{\overline{OD}^2}{\overline{AB}}$$

$$e = \frac{2\overline{AC}}{\overline{AB}}$$

$\varphi$ = polar angle between vector $\rho$ and the polar axis *Ox*. Point *P* describes an ellipse when $e < 1$, a parabola when $e = 1$ and a hyperbola when $e > 1$.




The inversion condition $\overline{OB} \times \overline{OP} = \overline{OD^2}$ is always complied with. Link *2*, turning about fixed axis *O*, is connected by sliding pairs to sliders *6*, *9* and *3*. Link *7* has the form of a bent lever and turns about axis *O*. Link *7* is connected by turning pair *D* to slider *1* and its arm *Da* moves in slider *8*. Slider *1* moves along axis *Eb* of link *5*. Link *5* is connected by turning pair *E* to slider *4* and by a sliding pair to cross-shaped slider *6* which has guides perpendicular to each other. Sliders *8* and *9* are connected together by turning pair *P*. Slider *3* is connected by turning pair *C* to slider *4* which moves along fixed guides *p-p* whose axis is parallel to axis *Oy*. When link *2* turns about axis *O*, point *P* describes a conic section with the equation

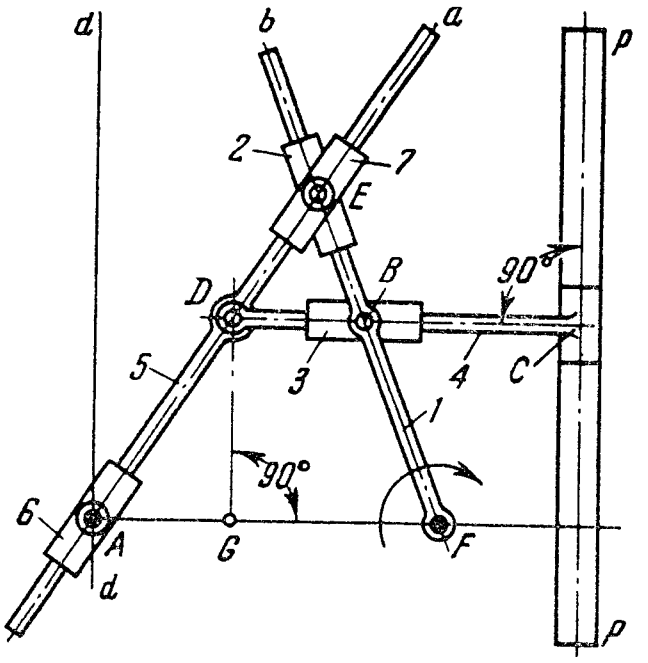
$$y^2 = 2px - (1 - e^2)\, x^2$$

where $2p = \dfrac{\overline{OD^2}}{\overline{OC}}$

$$e^2 = \frac{\overline{EC}}{\overline{OC}}.$$

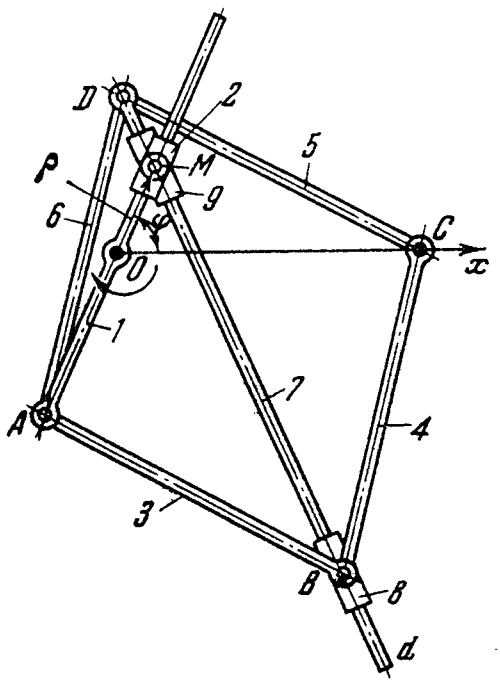
Point *P* describes an ellipse when $e < 1$, a parabola when $e = 1$ and a hyperbola when $e > 1$.

| 1123 | ARTOBOLEVSKY LINK-GEAR CONICOGRAPH | LG<br>Ge |
|---|---|---|




Link *1*, turning about fixed axis *F*, is connected by turning pair *B* to slider *3*. Slider *3* moves along axis *CD* of the extension of slider *4* which moves along fixed guides *p-p*. Sliders *7* and *2*, connected together by turning pair *E*, move along axes *Da* and *Fb* of links *5* and *1*. Link *5* moves in slider *6* which turns about fixed axis *A*. Centre *F* is placed at the focus of a conic section, centre *A* is placed on the given directrix *d-d* at its intersection with the perpendicular drawn from point *F*, and the condition $\overline{GF} : \overline{GA} = \overline{FB} : \overline{GA} = e$ is complied with, where *e* is the given eccentricity. Then, when link *1* turns about axis *F*, point *E* describes a conic section. Point *E* describes an ellipse when $e < 1$, a parabola when $e = 1$ and a hyperbola when $e > 1$.

| 1124 | LINK-GEAR CONICOGRAPH MECHANISM WITH A STRAIGHT ENVELOPING LINE | LG Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AD} = \overline{DC} = \overline{CB} = \overline{BA}$. Figure $ADCB$ is a rhombus linkage. Link *1*, turning about fixed axis *O*, is connected by a sliding pair to slider *2* and by turning pair *A* to links *3* and *6*. Link *7* moves in sliders *8* and *9*, and is connected by turning pair *D* to links *5* and *6*. Links *4* and *5* turn about fixed axis *C*. Slider *8* is connected by turning pair *B* to links *3* and *4*. Sliders *2* and *9* are connected together by turning pair *M*. When link *1* turns about axis *O*, point *M* describes a conic section with the equation

$$\rho = \frac{p}{1 + e\cos\varphi}$$

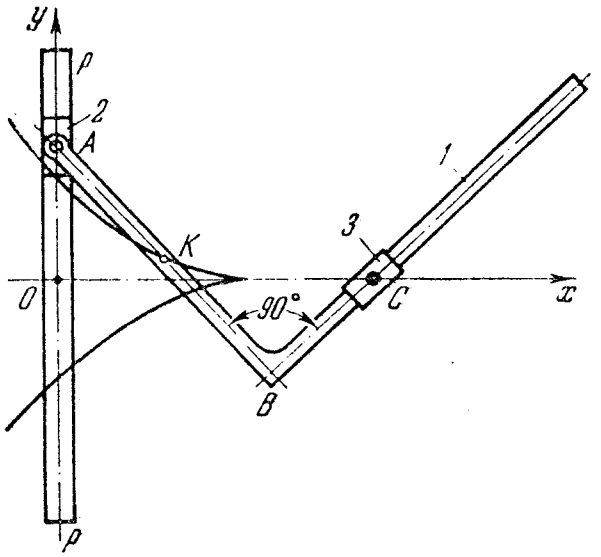
where $\rho = \overline{OM}$

$$p = \frac{\overline{OC}^2 - \overline{OA}^2}{2\overline{OA}}$$

$$e = \frac{\overline{OC}}{\overline{OA}}$$

$\varphi$ = polar angle between vectors and the polar axis $Ox$. Point *M* describes an ellipse when $e < 1$, a parabola when $e = 1$ and a hyperbola when $e > 1$. At the same time, straight line *Dd* envelops the conic section traced by point *M*.

| 1125 | NEWTON'S FOUR-BAR LINK-GEAR MECHANISM FOR TRACING CISSOIDS OF DIOCLES | LG Ge |
|---|---|---|



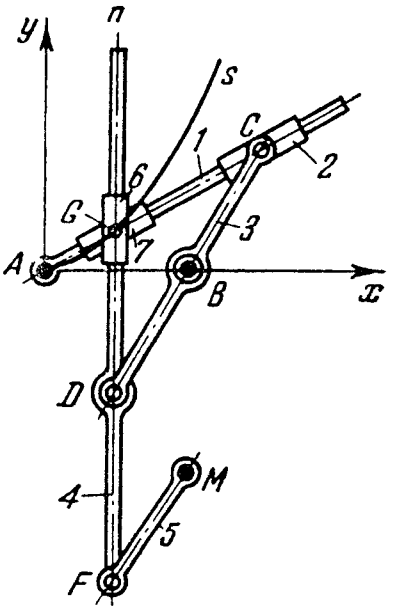

Slider *2* moves along fixed guides *p-p*. Link *1* is connected by turning pair *A* to slider *2* and by a sliding pair to slider *3*. Slider *3* turns about fixed axis *C*. When slider *2* moves along guides *p-p*, point *K* of sliding link *1* describes a cissoid with the equation

$$y^2 = \frac{(d-x)^3}{d+x}$$

where $d = \overline{AK} = \overline{KB}$

$\overline{OC} = 2d$.

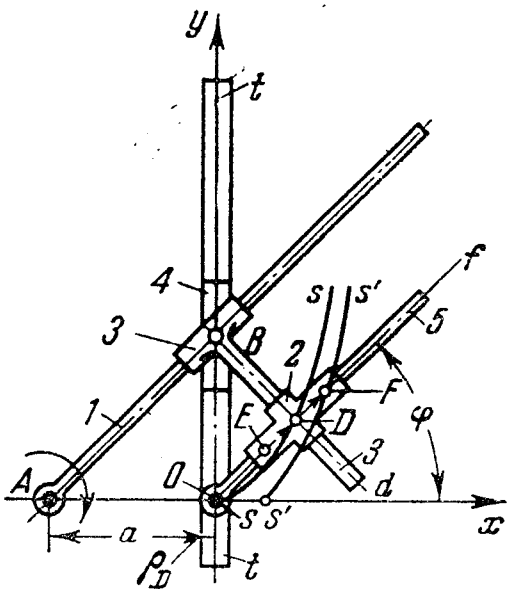
| 1126 | ARTOBOLEVSKY FOUR-BAR LINK-GEAR MECHANISM FOR TRACING CISSOIDS OF DIOCLES | LG Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{BC} = \overline{BD} = \overline{MF} = \overline{AB} = \frac{a}{2}$ and $\overline{DF} = \overline{BM}$. Figure $BDFM$ is a parallel-crank linkage. Link *1*, turning about fixed axis $A$, is connected by sliding pairs to sliders *7* and *2*. Link *3*, turning about fixed axis $B$, is connected by turning pairs $C$ and $D$ to slider *2* and link *4*. Link *4* is connected by turning pair $F$ to link *5* which turns about fixed axis $M$. Slider *6* is connected to slider *7* by turning pair $G$ and moves along axis $Fn$ of link *4*. When link *1* turns about axis $A$, point $G$ describes cissoid of Diocles $s$ with the equation

$$y^2 = \frac{x^2}{a - x}.$$

| 1127 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING CISSOIDS OF DIOCLES AND THEIR CONCHOIDS | LG Ge |
|---|---|---|




The lengths of the links comply with the condition: $\overline{DE} = \overline{DF} = b$. Link *1*, turning about fixed axis *A*, is connected by a sliding pair to slider *3*. Cross-piece *Bd* of slider *3* moves in cross-shaped slider *2* which has guides perpendicular to each other. Slider *4* moves along fixed guides *t-t* whose axis is perpendicular to axis *Ax*. Slider *4* is connected by turning pair *B* to slider *3*. Slider *2* moves along axis *Of* of link *5* which turns about fixed axis *O*. When link *1* turns about axis *A*, point *D* of slider *2* describes cissoid of Diocles *s-s* with the equation

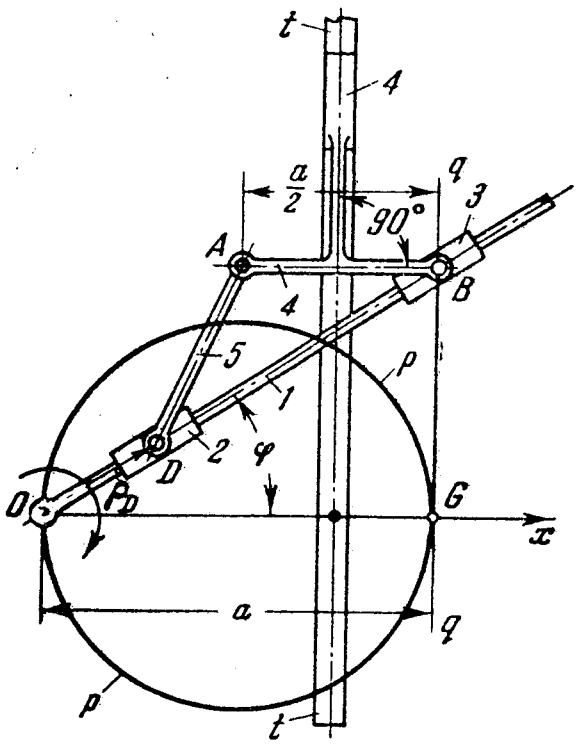
$$\rho_D = \overline{OD} = a\,\frac{\sin^2\varphi}{\cos\varphi}\,.$$

Points *E* and *F* describe conchoid *s'-s'* of cissoid *s-s*. The equation of conchoid *s'-s'* is

$$\rho_F = \rho_D \pm b$$

where $\varphi$ is the polar angle between vector $\rho_D$ and the polar axis *Ox*. The branch of the conchoid described by point *F* is shown.

| 1128 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING CISSOIDS OF DIOCLES | LG Ge |
|---|---|---|

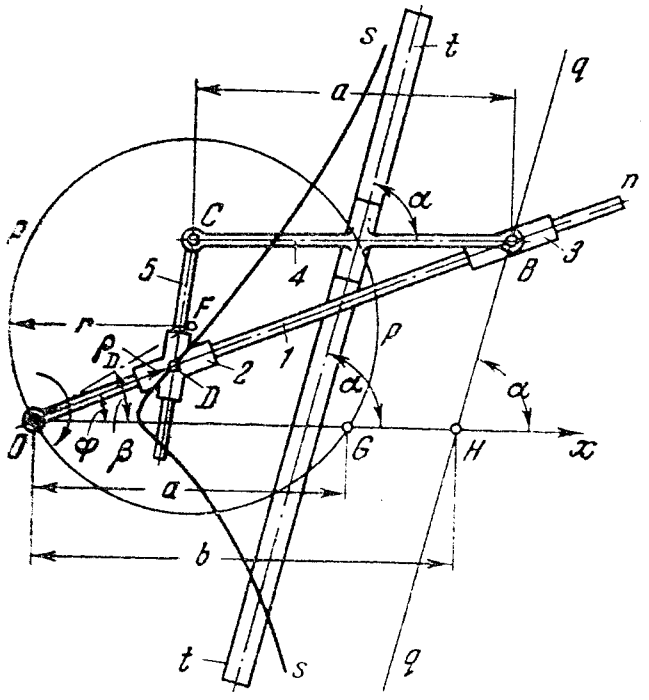



The length of the links comply with the condition: $\overline{AD} = \overline{AB} = \frac{a}{2}$. Link *1*, turning about fixed axis *O*, is connected by sliding pairs to sliders *2* and *3*. Slider *4* moves along fixed guides *t-t* whose axis is perpendicular to axis *Ox*. Cross-piece *AB* of slide *4* is connected by turning pairs *A* and *B* to link *5* and slider *3*. Link *5* is connected by turning pair *D* to slider *2*. When link *1* turns about axis *O*, point *D* of slider *2* describes a cissoid of Diocles. This is the cissoid of circle *p-p*, of radius $\frac{a}{2}$ and passing through point *O*, and of straight line *q-q* tangent to circle *p-p* at point *G*. The equation of the cissoid of Diocles is

$$\rho_D = \overline{OD} = \frac{a}{\cos\varphi} - a\cos\varphi \quad \text{or} \quad y^2 = \frac{x^3}{a-x}$$

where φ is the polar angle between vector $\rho_D$ and polar axis

# ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING CISSOIDS




Link 1, turning about fixed axis $O$, is connected by sliding pairs to sliders 2 and 3. Slider 4 moves along fixed guides $t$-$t$ whose axis makes the angle $\alpha$ with axis $Ox$. Cross-piece $CB$ of slider 4 is connected by turning pair $C$ to link 5. Link 5 moves in T-shaped slider 2 which has guides making the angle $90° - \beta$ with each other, where $\beta$ is the angle between radius $\overline{OF} = r$ of circle $r$-$r$ and axis $Ox$, and equals

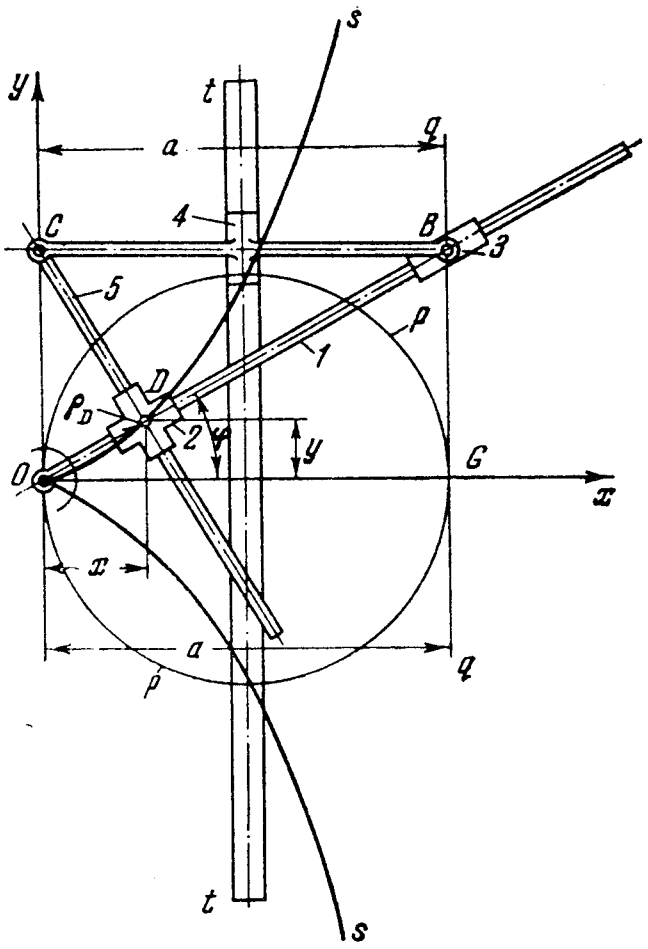
$$\beta = \arccos \frac{a}{2r}.$$

Slider 3 is connected by turning pair $B$ to slider 4. When link 1 turns about axis $O$, point $D$ of slider 2 describes cissoid $s$-$s$ of circle $r$-$r$, of radius $r$ and passing through point $O$, and of straight line $p$-$q$. The equation of the cissoid is

$$\rho_D = \overline{OD} = b \cdot \frac{\sin \alpha}{\sin (\alpha - \varphi)} - 2r \cos (\beta - \varphi)$$

where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis $Ox$.

| 1130 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING CISSOIDS OF DIOCLES | LG Ge |
|---|---|---|




Link *1*, turning about fixed axis *O*, is connected by sliding pairs to sliders *2* and *3*. Slider *4* moves along fixed guides *t-t* whose axis is perpendicular to axis *Ox*. Cross-piece *CB* of slider *4* is connected by turning pair *C* to link *5*. Link *5* moves in cross-shaped slider *2* which has guides perpendicular to each other. Slider *3* is connected by turning pair *B* to slider *4*. When link *1* turns about axis *O*, point *D* of slider *2* describes cissoid of Diocles *s-s* with the equation

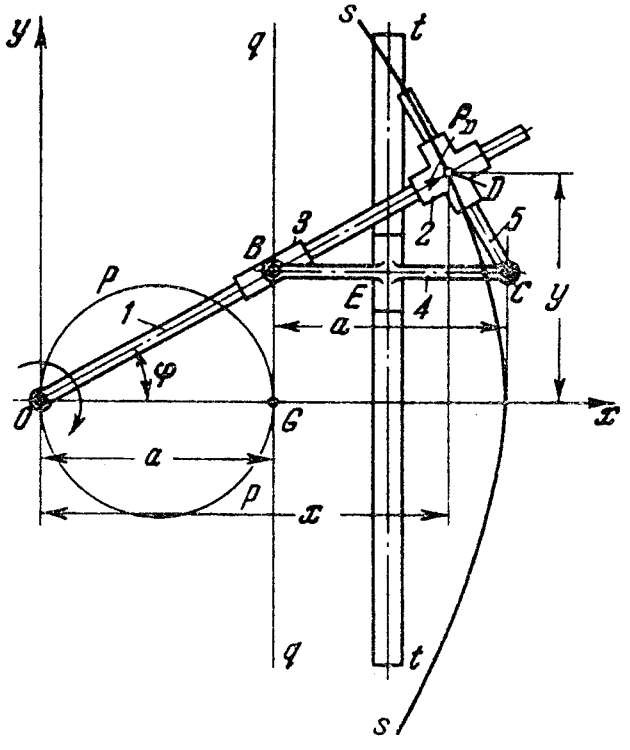
$$\rho_D = \overline{OD} = a\frac{\sin^2\varphi}{\cos\varphi} \quad \text{or} \quad y^2 = \frac{x^3}{a-x}$$

where $a$ = diameter of circle *p-p*

$\varphi$ = polar angle between vector $\rho_D$ and polar axis *Ox*.

The cissoid of Diocles is a cissoid of circle *p-p*, of diameter $a$ and passing through point *O*, and of straight line *q-q* tangent to this circle at point *G*.

| 1131 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING THE COMPANIONS OF CISSOIDS OF DIOCLES | LG Ge |
|---|---|---|




Link *1*, turning about fixed axis *O*, is connected by sliding pairs to sliders *3* and *2*. Slider *4* moves along fixed guides *t-t* whose axis is perpendicular to axis *Ox*. Cross-piece *BC* of slider *4* is connected by turning pair *C* to link *5*. Link *5* moves in cross-shaped slider *2* which has guides perpendicular to each other. Slider *3* is connected by turning pair *B* to slider *4*. When link *1* turns about axis *O*, point *D* of slider *2* describes companion curve *s-s* of a cissoid of Diocles, with the equation

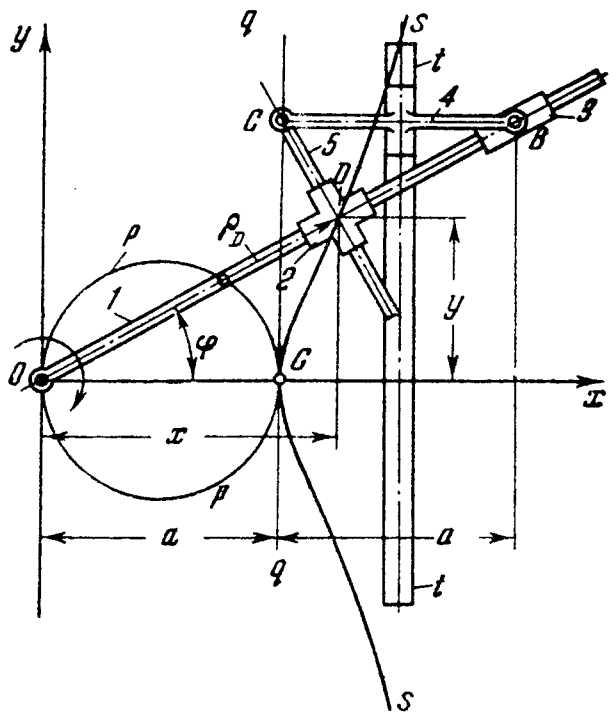
$$\rho_D = \overline{OD} = \frac{a}{\cos\varphi} + a\cos\varphi \quad \text{or} \quad y^2 = \frac{x^2(2a-x)}{x-a}$$

where $a$ = diameter of circle *p-p*

$\varphi$ = polar angle between vector $\rho_D$ and polar axis *Ox*.

Curve *s-s* is a companion curve of a cissoid of Diocles, i.e. a cissoid of circle *p-p*, of diameter *a* and passing through point *O*, and of straight line *q-q* tangent to this circle at point *G*.

| 1132 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING THE CONCOMITANT CURVES OF CISSOIDS OF DIOCLES | LG Ge |
|---|---|---|

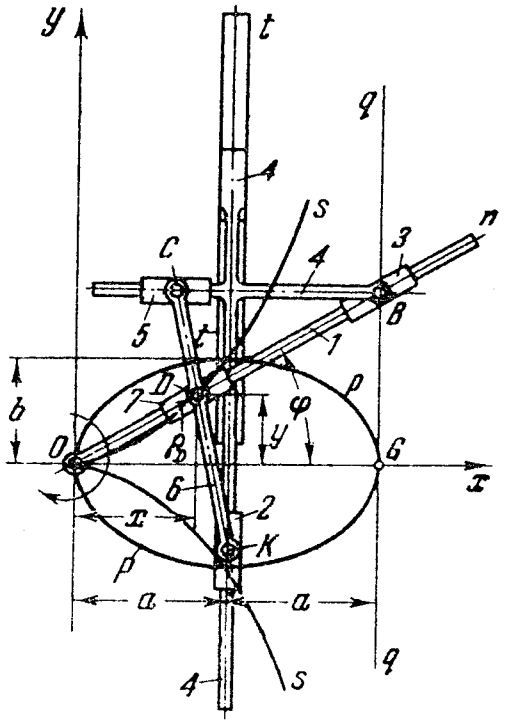



Link *1*, turning about fixed axis *O*, is connected by sliding pairs to sliders *2* and *3*. Slider *4* moves along fixed guides *t-t* whose axis is perpendicular to axis *Ox*. Cross-piece *CB* of slider *4* is connected by turning pair *C* to link *5*. Link *5* moves in cross-shaped slider *2* which has guides perpendicular to each other. Slider *3* is connected by turning pair *B* to slider *4*. When link *1* turns about axis *O*, point *D* of slider *2* describes curve *s-s*, accompanying a cissoid of Diocles, with the equation

$$\rho_D = \overline{OD} = \frac{2a}{\cos\varphi} - a\cos\varphi \quad \text{or} \quad y^2 = \frac{x^2(x-a)}{2a-x}$$

where $a$ = diameter of circle *p-p*
$\varphi$ = polar angle between vector $\rho_D$ and polar axis *Ox*.

| 1133 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING CISSOIDS OF ELLIPSES | LG Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{DK} = a$ and $\overline{DC} = b$, where $a$ and $b$ are the semiaxes of ellipse $p$-$p$. Link *1*, turning about fixed axis $O$, is connected by sliding pairs to sliders *7* and *3*. Cross-shaped slider *4* moves along fixed guides $t$-$t$ whose axis is perpendicular to axis $Ox$. Cross-piece $CB$ of slider *4* is connected by a sliding pair to slider *5* and by turning pair $B$ to slider *3*. Link *6* is connected by turning pairs $C$, $D$ and $K$ to sliders *5*, *7*, and *2*. Slider *2* is connected by a sliding pair to slider *4*. When link *1* turns about axis $O$, point $D$ of link *6* describes cissoid $s$-$s$ of ellipse $p$-$p$ and of straight line $q$-$q$ tangent to this ellipse at point $G$. The equation of curve $s$-$s$ is

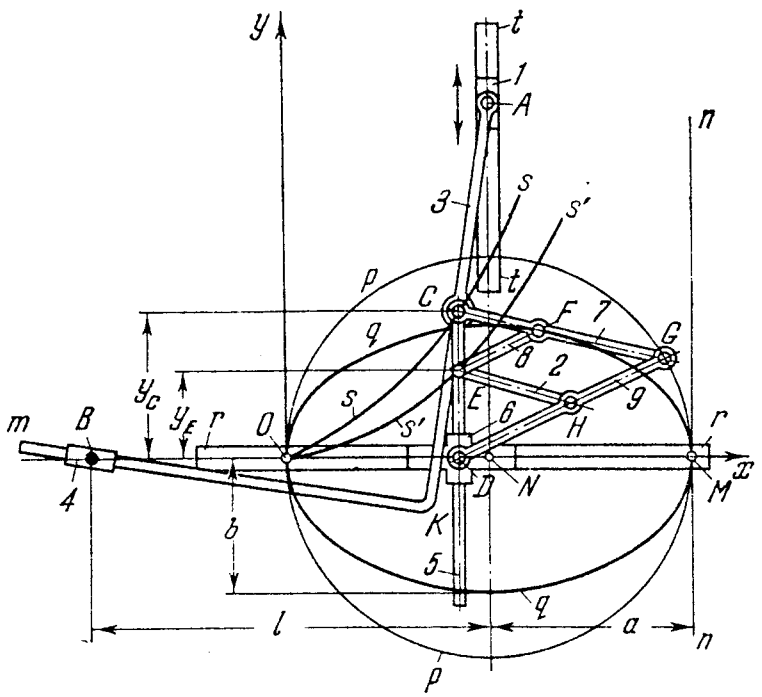
$$\rho_D = \overline{OD} = \frac{2a}{\cos\varphi} - \frac{2\frac{b^2}{a}\cos\varphi}{\sin^2\varphi + \frac{b^2}{a^2}\cos^2\varphi}$$

or

$$y^2 = \frac{b^2}{a^2}\frac{x^3}{2a-}$$

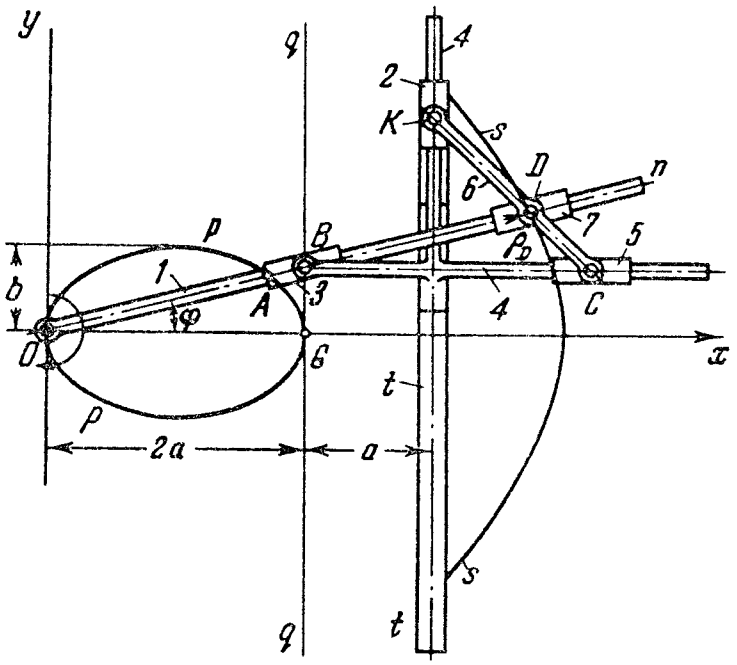
where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis $Ox$.

| 1134 | LINK-GEAR MECHANISM FOR TRACING CISSOIDS OF ELLIPSES | LG Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{KC} = \overline{CA}$, $\overline{BN} = \overline{AK} = l$, $\overline{CG} : \overline{GD} = \overline{EH} : \overline{DH}$, $\overline{CF} = \overline{EF}$ and $k = b^2/a^2$, where $a$ and $b$ are the semiaxes of ellipse $q$-$q$. Slider *1* moves along fixed guides $t$-$t$ whose axis is parallel to axis $Oy$ and passes through centre $N$ of circle $p$-$p$ with the radius $a = l/2$. Link *3* has the form of a bent lever and is connected by turning pair $A$ to slider *1*. Arm $Km$ of link *3* moves in slider *4* which turns about fixed axis $B$. Cross-shaped slider *6*, which has guides perpendicular to each other, moves along guides $r$-$r$ whose axis coincides with axis $Ox$. Link *9* is connected by turning pairs $H$, $G$ and $D$ to links *2* and *7*, and to slider *6*. Link *7* is connected by turning pairs $C$ and $F$ to links *3* and *8*. Links *2* and *8* are connected by turning pair $E$. Link *5*, connected by turning pair $C$ to link *3*, moves in slider *6*. When slider *1* moves along guides $t$-$t$, point $C$ of link *3* describes cissoid $s$-$s$ of circle $p$-$p$ and of straight line $n$-$n$ tangent to this circle at point $M$. Point $E$, the centre of the turning pair connecting links *2* and *8*, describes cissoid $s'$-$s'$ of ellipse $q$-$q$ and of the tangent $n$-$n$. The relation of the ordinates $y_E$ and $y_C$ of curves $s$-$s$ and $s'$-$s'$ is always $y_E = ky_C$.

| 1135 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING THE COMPANIONS OF CISSOIDS OF ELLIPSES | LG Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{DK} = a$ and $\overline{DC} = b$, where $a$ and $b$ are the semiaxes of the ellipse. Link *1*, turning about fixed axis *O*, is connected by sliding pairs to sliders *3* and *7*. Cross-shaped slider *4* moves along fixed guides *t-t* whose axis is perpendicular to axis *Ox*. Slider *4* is connected by a sliding pair to slider *5* and by turning pair *B* to slider *3*. Link *6* is connected by turning pairs *C*, *D* and *K* to sliders *5*, *7* and *2*. Slider *2* is connected by a sliding pair to an extension of slider *4*. When link *1* turns about axis *O*, point *D* of link *6* describes companion curve *s-s* of the cissoid of ellipse *p-p* and of its tangent *q-q* at point *G*. The equation of curve *s-s* is

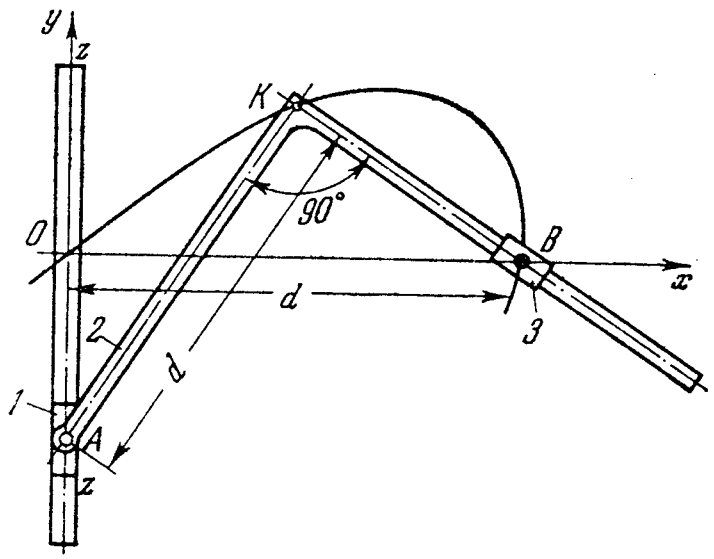
$$\rho_D = \overline{OD} = \frac{2a}{\cos\varphi} + \frac{2\frac{b^2}{a}\cos\varphi}{\sin^2\varphi + \frac{b^2}{a^2}\cos^2\varphi}$$

or

$$y^2 = \frac{x^2(4p - x)}{x - 2a}$$

where $\varphi$ = polar angle between vector $\rho_D$ and polar axis *Ox*
$p = b^2/a$.

| 1136 | FOUR-BAR LINK-GEAR MECHANISM FOR TRACING STROPHOIDS | LG Ge |
|---|---|---|

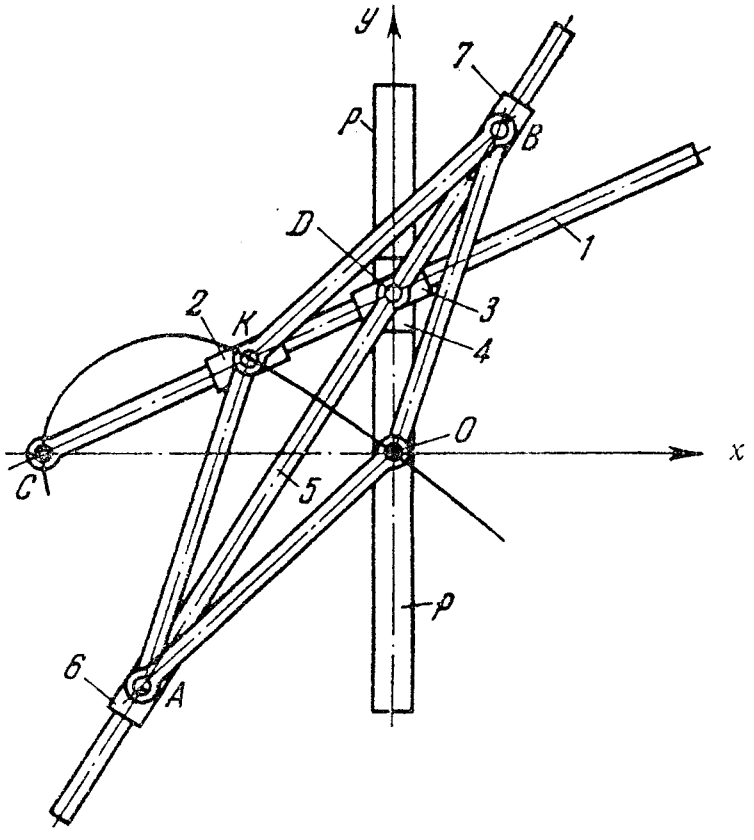



Slider *1* moves along fixed guides *z-z*. Link *2* is connected by turning pair *A* to slider *1* and by a sliding pair to slider *3* which turns about fixed axis *B*. When slider *1* moves along guides *z-z*, point *K* of link *2* describes a strophoid with the equation

$$y^2 = x^2 \frac{d-x}{d+x}$$

where $d = \overline{AK} = \overline{OE}$.

| 1137 | VYATKIN LINK-GEAR MECHANISM FOR TRACING STROPHOIDS | LG Ge |
|---|---|---|

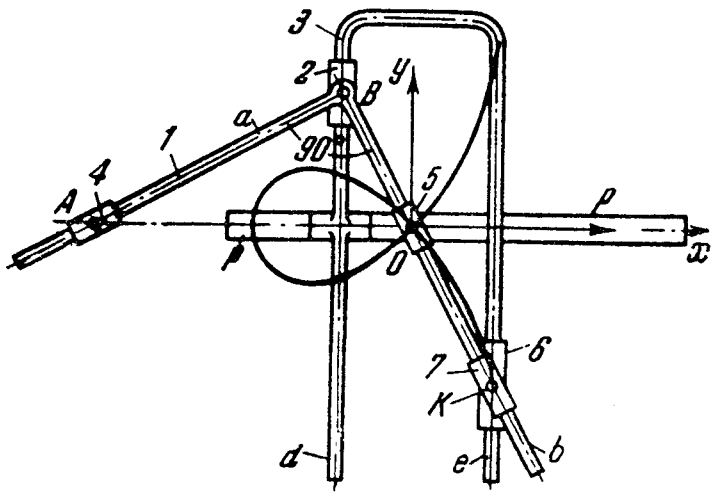



The lengths of the links comply with the conditions: $\overline{AK} = \overline{KB} = \overline{BO} = \overline{OA}$, i.e. figure $AKBO$ is a rhombus linkage. Slider *4* moves along fixed guides *p-p*. Sliding link *1* turns about fixed axis *C*. Link *1* moves in sliders *2* and *3*. Sliders *3* and *4* are connected together by turning pair *D*. Link *5*, whose axis forms diagonal *AB* of rhombus linkage *AKBO*, is connected by turning pair *D* to sliders *3* and *4*. Link *5* moves in sliders *6* and *7* which are connected by turning pairs *A* and *B* to the links of the rhombus linkage. When sliding link *1* turns about axis *C*, point *K* describes a strophoid with the equation

$$y^2 = x^2 \frac{a-x}{a+x}$$

where $a = \overline{OC}$.

| 1138 | LINK-GEAR MECHANISM FOR TRACING STROPHOIDS | LG Ge |
|---|---|---|

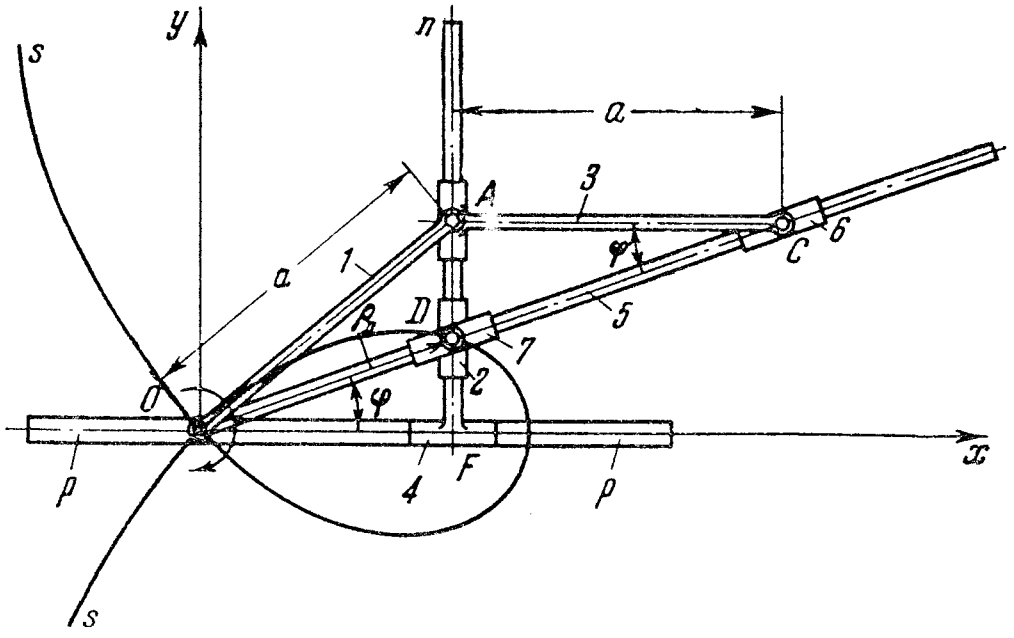



Link *1* has the form of a bent lever and its arms *a* and *b* move in sliders *4* and *5* which turn about fixed axes *A* and *O*. Link *1* is connected by turning pair *B* to slider *2*. Slider *2* moves along leg *d* of frame *3* which slides along fixed guides *p-p*. Sliders *6* and *7*, connected together by turning pair *K*, move along leg *e* of frame *3* and arm *b* of link *1*. When frame *3* slides along guides *p-p*, point *K* describes the loop of a strophoid with the equation

$$y^2 = x^2 \frac{c-x}{c+x}$$

where $c$ is the distance between the vertical legs *d* and *e* of frame *3* and is equal to $c = \frac{\overline{AO}}{2}$.

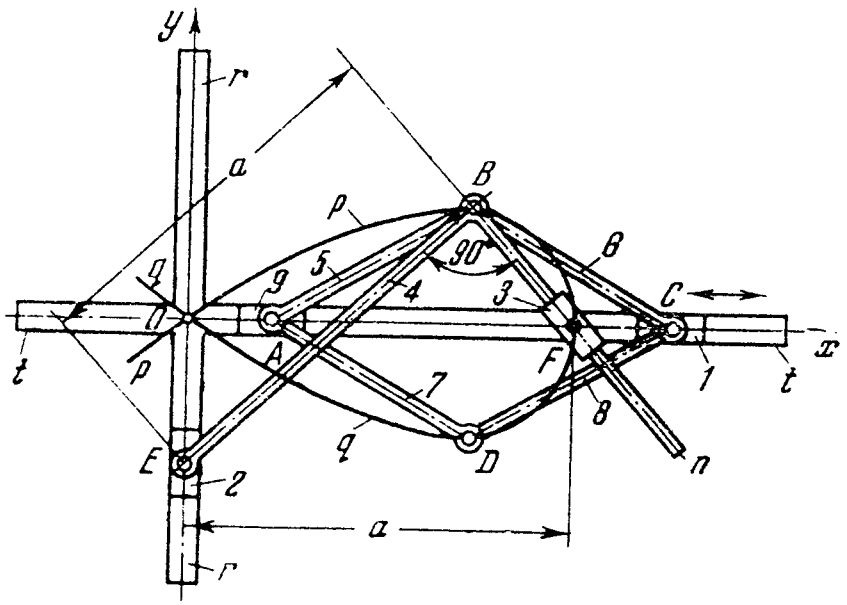
1139 **ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING STROPHOIDS** LG Ge




The lengths of the links comply with the condition: $\overline{OA} = \overline{AC} = a$. Link *1*, turning about fixed axis *O*, is connected by turning pair *A* to slider *3*. Slider *3* moves along cross-piece *Fn* of slider *4* which moves along fixed guides *p-p* whose axis coincides with axis *Ox*. Link *5*, turning about axis *O*, is connected by sliding pairs to sliders *6* and *7*. Sliders *2* and *7* are connected together by turning pair *D*. When link *1* turns about axis *O*, point *D* traces strophoid *s-s* with the equation

$$\rho_D = \overline{OD} = a\,\frac{\cos 2\varphi}{\cos \varphi}$$

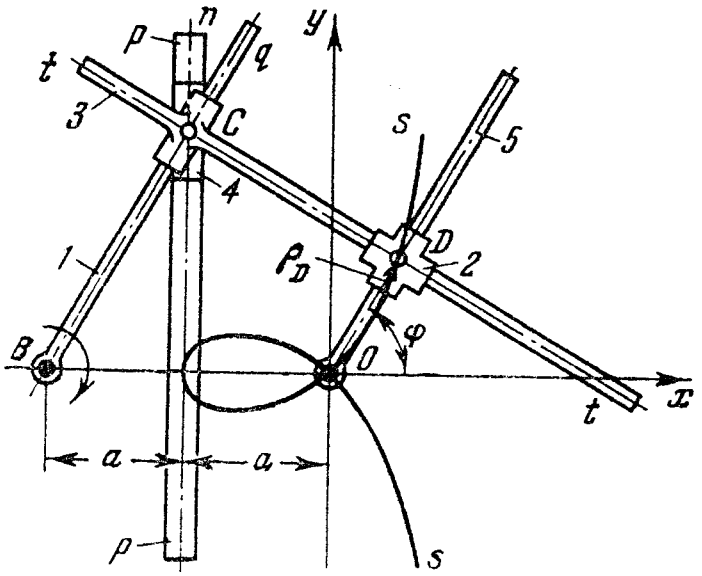
where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis *Ox*.




The lengths of the links comply with the conditions: $\overline{AB} = \overline{BC} = \overline{CD} = \overline{DA}$ and $\overline{EB} = \overline{OF} = a$. Figure $ABCD$ is a rhombus linkage. Link *4* has the form of a bent lever. Arm $Bn$ of link *4* moves in slider *3* which turns about fixed axis $F$. Link *4* is connected by turning pair $E$ to slider *2* which moves along fixed guides *r-r*. Sliders *1* and *9* move along fixed guides *t-t*. Points $B$ and $D$ trace a strophoid. Point $B$ traces portion *p-p* of the strophoid, and point $D$ traces portion *q-q* which is the mirror image of portion *p-p* with respect to axis $Ox$. The equation of the strophoid is

$$y^2 = x^2 \frac{a-x}{a+x}.$$

1141 **ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING STROPHOIDS** LG Ge

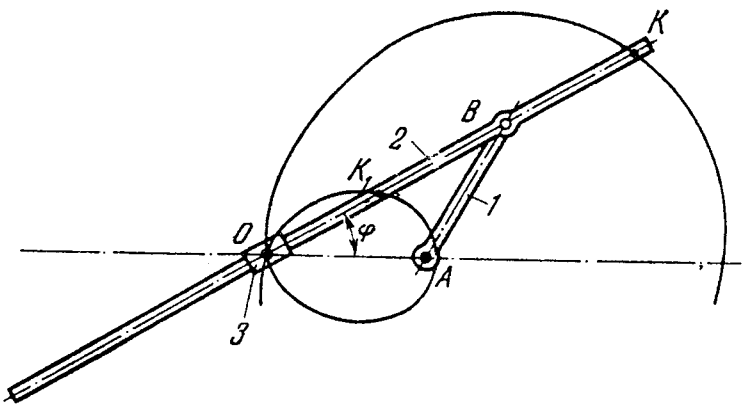



Link *1*, turning about fixed axis *B*, is connected by a sliding pair to slider *3*. Slider *3* is connected by turning pair *C* to slider *4* which moves along fixed guides *p-p* whose axis is perpendicular to axis *Ox*. Cross-piece *t-t* of link *3* is perpendicular to axis *Bq* and is connected by a sliding pair to cross-shaped slider *2* which has guides perpendicular to each other. Link *5*, turning about fixed axis *O*, is connected by a sliding pair to slider *2*. When link *1* turns about axis *B*, point *D* describes strophoid *s-s* with the equation

$$\rho_D = \overline{OD} = a\frac{\cos 2\varphi}{\cos \varphi}$$

where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis *Ox*.

| 1142 | FOUR-BAR SLIDING-LINK MECHANISM FOR TRACING LIMACONS | LG Ge |
|---|---|---|




Crank *1*, turning about fixed axis *A*, is connected by turning pair *B* to link *2* which moves in slider *3*. Slider *3* turns about fixed axis *O*. When crank *1* turns about axis *A*, point *K* (and $K_1$) describes a limaçon whose polar equation with respect to centre *O* is of the form

$$\rho_K = 2r \cos \varphi \pm b$$

where $b = \overline{KB} = \overline{BK_1}$

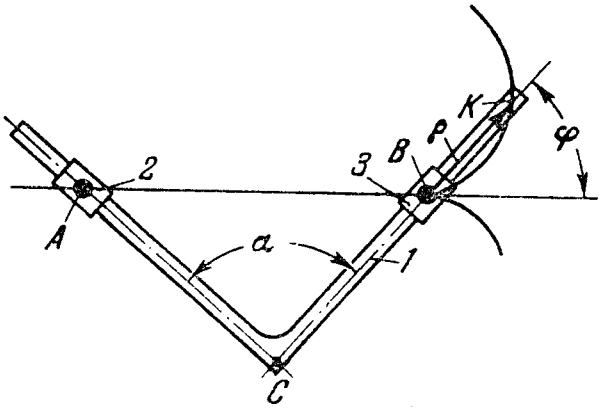
$r = \overline{OA}$

$\rho_K$ = radius vector drawn from centre *O* to point *K* ($K_1$)

$\varphi$ = polar angle.

## 1143 FOUR-BAR SLIDING-LINK MECHANISM FOR TRACING CARDIOIDS






When bent sliding link *1* slides in guides *2* and *3*, which turn about fixed axes *A* and *B*, point *K* of the link describes a cardioid with the equation

$$\rho = b - 2a\,\frac{\sin(\alpha+\varphi)}{\sin\alpha}$$

where $a = \dfrac{\overline{AB}}{2}$

$b = \overline{CK}$

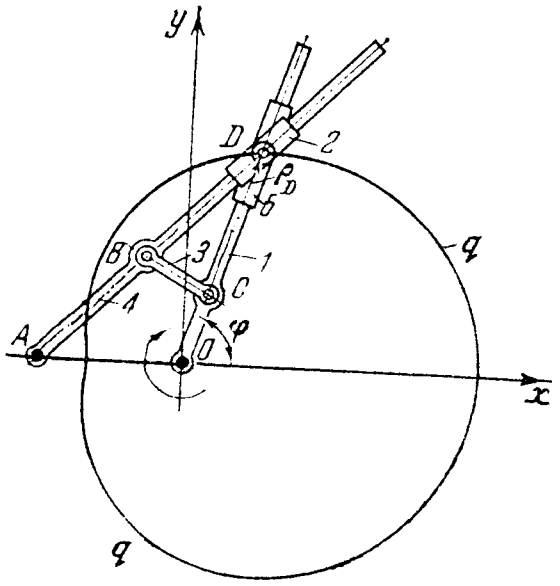
$\rho = \overline{BK}$

$\varphi$ = polar angle

$\alpha$ = angle $ACB$ of bent sliding lever *1*.

If $\alpha = \pi/2$ and $a = b$, then the equation of the cardioid is

$$\rho = 2a\,(1 - \cos\varphi).$$




The length of the links comply with the conditions: $\overline{AB} = \overline{AO} = a$ and $\overline{BC} = \overline{CO} = f$. Figure $ABCO$ is a rhomboid linkage. Link *1*, turning about fixed axis $O$, is connected by turning pair $C$ to link *3* and by a sliding pair to slider *5*. Link *4*, turning about fixed axis $A$, is connected by turning pair $B$ to link *3* and by a sliding pair to slider *2*. Sliders *2* and *5* are connected together by turning pair $D$. When link *1* rotates about point $O$, point $D$ describes a limaçon with the equation

$$\rho_D = \overline{OD} = a \cos \varphi + b$$

where $a = \dfrac{2df^2}{d^2 - f^2}$

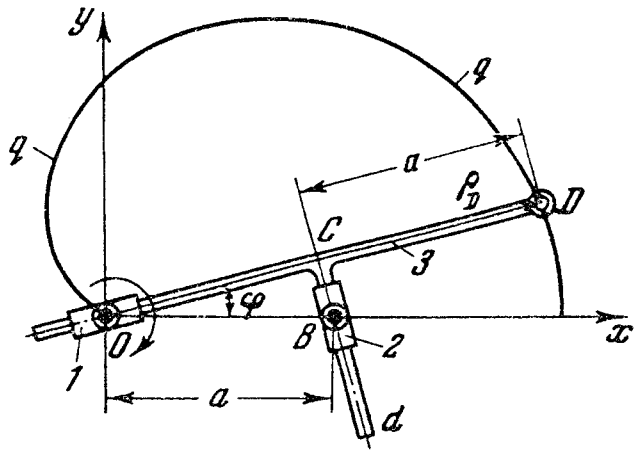
$$b = \frac{2d^2 f}{d^2 - f^2}$$

$\varphi$ = polar angle between vector $\rho_D$ and polar axis $Ox$.

1145

# LINK-GEAR MECHANISM FOR TRACING CARDIOIDS

LG Ge

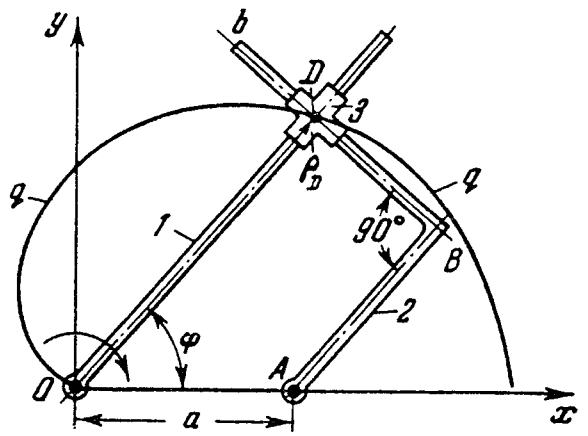



The lengths of the links comply with the conditions: $\overline{OB} = \overline{CD} = a$. Slider *1* turns about fixed axis *O*. Link *3* is connected by a sliding pair to slider *1*. Cross-piece *Cd* of link *3* is connected by a sliding pair to slider *2* which turns about fixed axis *B*. When slider *1* turns about axis *O*, point *D* of link *3* describes cardioid *q-q*. The same cardioid is also described by another point of link *3*, located at the distance *a* to the left of point *C*. The equation of the cardioid is

$$\rho_D = \overline{OD} = a\,(1 + \cos\varphi)$$

where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis *Ox*.

| 1146 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING CARDIOIDS | LG Ge |
|---|---|---|

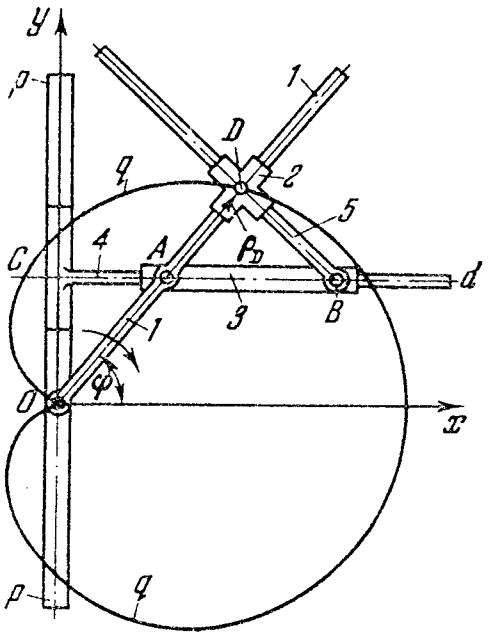



The lengths of the links comply with the condition: $\overline{OA} = \overline{AB} = a$. Link *1*, turning about fixed axis *O*, is connected by a sliding pair to cross-shaped slider *3* which has guides perpendicular to each other. Link *2* has the form of a bent lever and turns about fixed axis *A*. Arm *Bb* of link *2* moves in slider *3*. When link *1* turns about axis *O*, point *D* of slider *3* describes cardioid *q-q* with the equation

$$\rho_D = \overline{OD} = a\,(1 + \cos\varphi),$$

where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis *Ox*.

1147 **ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING CARDIOIDS** LG Ge

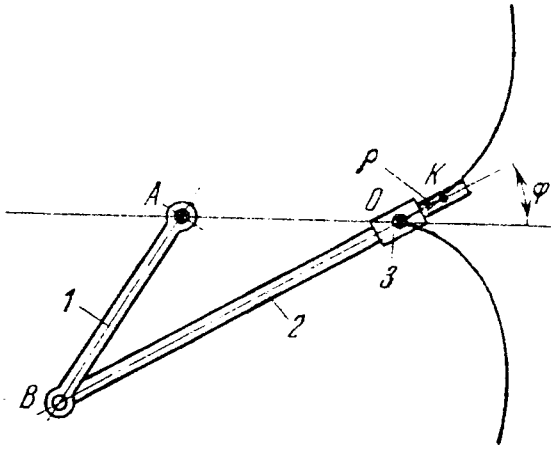



The lengths of the links comply with the conditions: $\overline{OA} = \overline{AB} = a$. Link *1*, turning about fixed axis *O*, is connected by turning pair *A* to slider *3* which moves along cross-piece *Cd* of slider *4*. Slider *4* moves along fixed guides *p-p* whose axis coincides with axis *Oy*. Link *1* is connected by a sliding pair to cross-shaped slider *2* which has guides perpendicular to each other. Link *5* is connected by turning pair *B* to slider *3* and by a sliding pair to slider *2*. When link *1* turns about axis *O*, point *D* of link *2* describes cardioid *q-q* with the equation

$$\rho_D = \overline{OD} = a\,(1 + \cos\varphi)$$

where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis *Ox*.

| 1148 | FOUR-BAR SLIDING-LINK MECHANISM FOR TRACING CARDIOIDS | LG Ge |
|---|---|---|




Crank *1*, rotating about fixed axis *A*, is connected by turning pair *B* to sliding link *2* which moves in slider *3*. Slider *3* turns about fixed axis *O*. When crank *1* rotates about axis *A*, point *K* of link *2* describes a cardioid with the equation

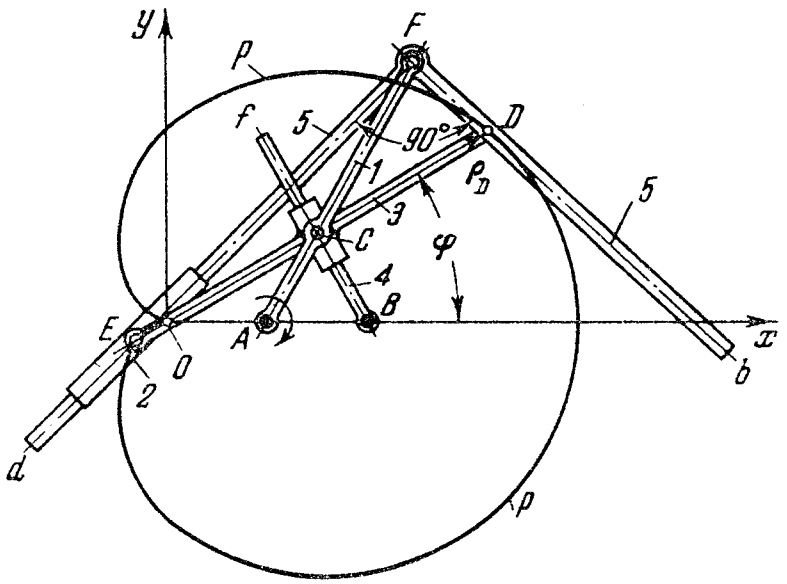
$$\rho = 2a\,(1 - \cos\varphi)$$

where $a = \overline{AO} = \overline{AB} = \dfrac{\overline{BK}}{2}$

$\rho$ = radius vector drawn from centre *O* to point *K*
$\varphi$ = polar angle.

1149 **ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING AND ENVELOPING CARDIOIDS**

LG Ge

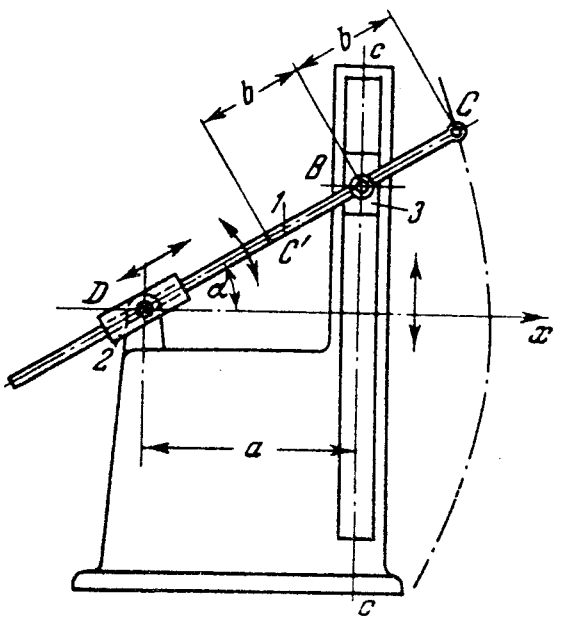



The lengths of the links comply with the conditions: $\overline{AC} = \overline{OA} = a$ and $\overline{DC} = \overline{CE} = 2a$. Link *1*, turning about fixed axis *A*, is connected by turning pair *C* to slider *3*. Slider *3* moves along axis *Bf* of link *4* which turns about fixed axis *B*. Link *5* has the form of a bent lever. Arm *Fd* of link *5* moves in slider *2* which is connected by turning pair *E* to cross-piece *ED* of slider *3*. When link *1* turns about axis *A*, points *D* and *E* describe cardioid *p-p* and arms *Fb* and *Fd* of link *5* envelop the cardioid. The equation of the cardioid is

$$\rho_D = \overline{OD} = 2a\,(1 + \cos\varphi)$$

where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis *Ox*.

| 1150 | FOUR-BAR SLIDING-LINK MECHANISM FOR TRACING CONCHOIDS OF A STRAIGHT LINE | LG Ge |
|---|---|---|



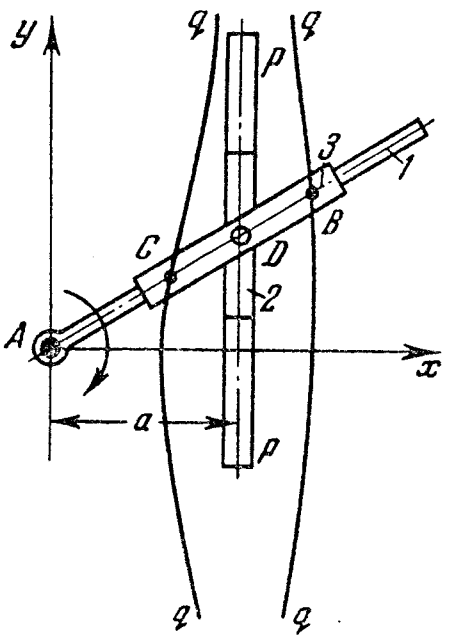

The mechanism is intended for tracing conchoids of Nicomedes of a straight line. Link *1* moves in slider *2* which turns about fixed axis *D*. Link *1* is connected by turning pair *B* to slider *3* which moves along fixed guides *c-c*. When link *2* turns about axis *D*, points *C* and *C'*, located at the distance *b* from point *B*, describe the two branches of a conchoid of straight line *c-c*. The equation of the conchoid in polar coordinates is

$$\overline{DC} = \frac{\overline{DB}}{\cos\alpha} \pm b.$$

In rectangular coordinates it is

$$(x - a)^2 (x^2 + y^2) = b^2 x^2.$$

| 1151 | LINK-GEAR MECHANISM FOR TRACING CONCHOIDS OF NICOMEDES | LG Ge |
|---|---|---|

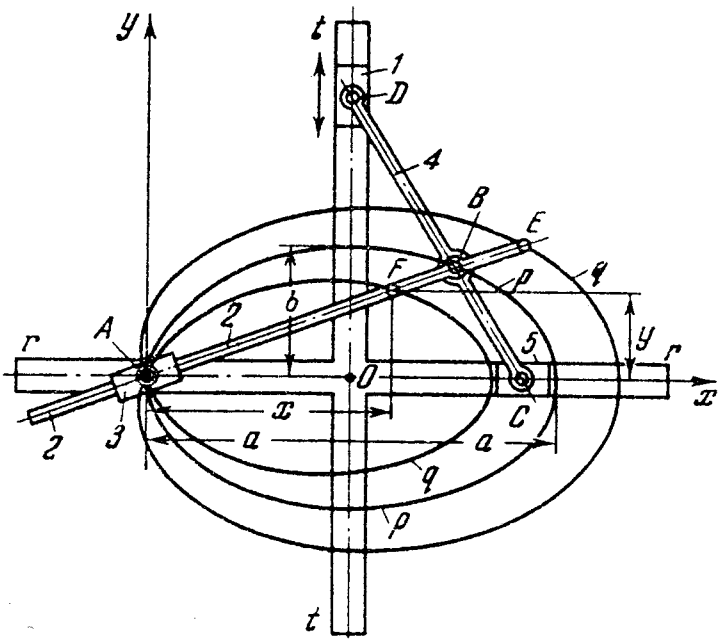



Link *1*, turning about fixed axis *A*, is connected by a sliding pair to slider *3*. Slider *3* is connected by turning pair *D* to slider *2* which moves along fixed guides *p-p*. When link *1* turns about axis *A*, points *B* and *C* of slider *3*, located at equal distances from point *D*, describe the two branches *q-q* of a conchoid of Nicomedes with the equation

$$(x - a)^2 (x^2 + y^2) = b^2 x^2$$

where $a$ = constant dimension of the mechanism
$b = \overline{DB} = \overline{CD}$.

| 1152 | LINK-GEAR MECHANISM FOR TRACING CONCHOIDS OF ELLIPSES | LG Ge |
|---|---|---|



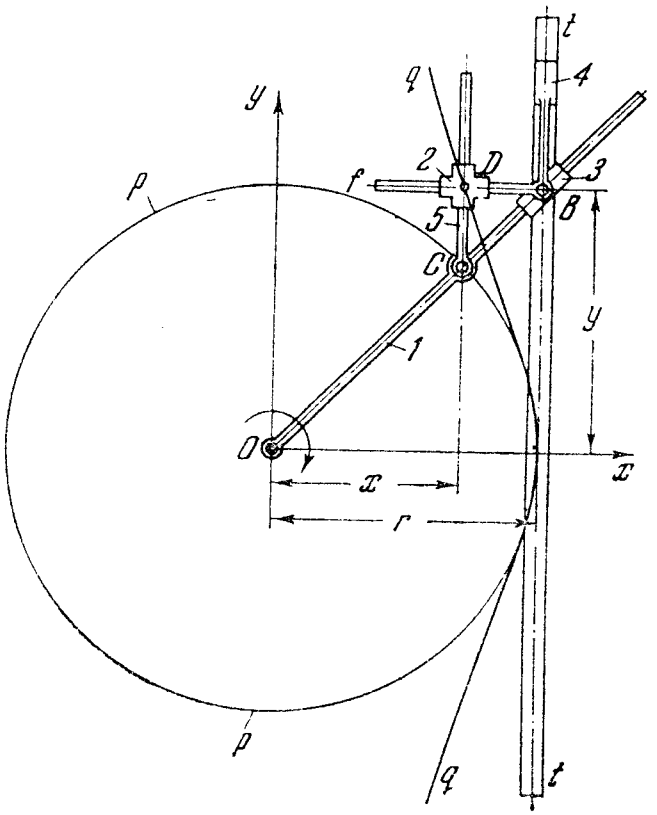

The lengths of the links comply with the conditions: $\overline{BD} = \overline{AO} = a$, $\overline{BC} = b$ and $\overline{FB} = \overline{BE} = d$, where $a$ and $b$ are semiaxes of ellipse $p$-$p$. Slider *1* moves along fixed guides $t$-$t$, whose axis is parallel to axis $Ay$ and passes through centre $O$ of ellipse $p$-$p$. Slider *1* is connected by turning pair $D$ to link *4* which, in turn, is connected by turning pairs $B$ and $C$ to link *2* and to slider *5*. Slider *5* moves along fixed guides $r$-$r$ whose axis coincides with axis $Ax$. Link *2* is connected by a sliding pair to slider *3* which turns about fixed axis $A$. When slider *1* moves along guides $t$-$t$, point $B$ of link *4* describes ellipse $p$-$p$, and points $F$ and $E$ of link *2* describe conchoid $q$-$q$ of ellipse $p$-$p$. The equation of the conchoid is

$$(y^2 + x^2)\,(a^2y^2 + b^2x^2 - 2abx^2)^2 = d\,(a^2y^2 + b^2x^2)^2.$$

If $d = 2a$, then points $F$ and $E$ describe a cardioid of ellipse $p$-$p$. The equation of the cardioid is

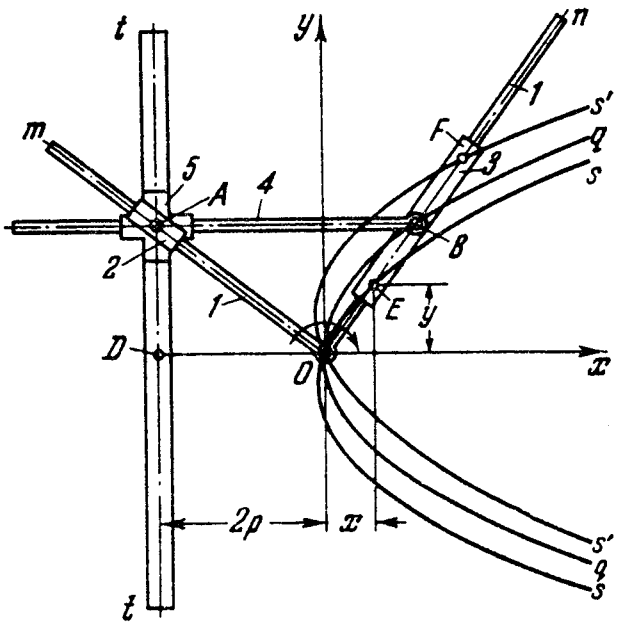
$$(y^2 + x^2)\,(a^2y^2 + b^2x^2 - 2ab^2x)^2 = 4a^2\,(a^2y^2 + b^2x^2)^2.$$

1153 **ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING CONCHOIDS OF KÜLP** LG Ge




The lengths of the links comply with the condition: $\overline{OC} = r$, where $r$ is the radius of circle $p$-$p$. The axis of guides $t$-$t$ is tangent to circle $p$-$p$. Link *1*, turning about fixed axis $O$, is connected by turning pair $C$ to link *5* and by a sliding pair to slider *3*. Slider *4* moves along fixed guides $t$-$t$ whose axis is parallel to axis $Oy$. Slider *4* is connected by turning pair $B$ to slider *3*. Arm $Bf$ of slider *4*, whose axis is parallel to axis $Ox$, is connected by a sliding pair to cross-shaped slider *2* which has guides perpendicular to each other. Link *5* is connected by a sliding pair to slider *2*. When link *1* turns about axis $O$, point $D$ of slider *2* describes conchoid $q$-$q$ of Külp with the equation

$$x^2 (r^2 + y^2) = r^4.$$



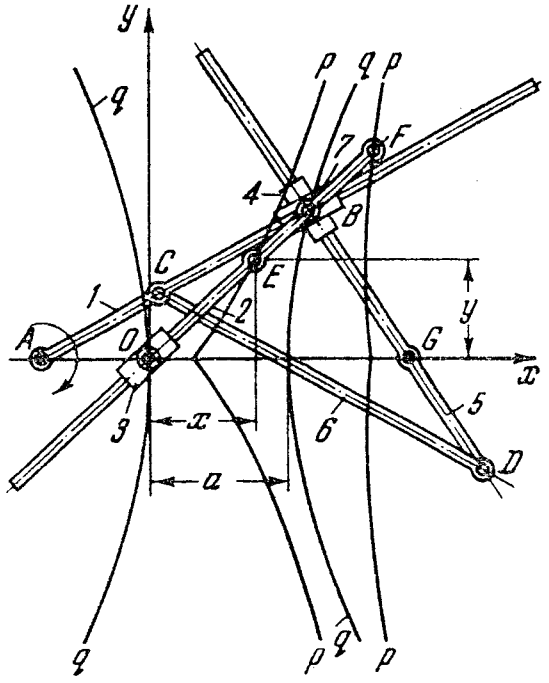

The lengths of the links comply with the condition: $\overline{DO} = 2p$, where $p$ is the distance from the focus of parabola $q$-$q$ to its directrix. Link *1* has the form of a bent lever with a right angle between its arms and turns about fixed axis $O$. Arm $On$ of link *1* is connected by a sliding pair to slider *3* and arm $Om$ by a sliding pair to slider *2*. Link *4* is connected by turning pair $B$ to slider *3* and by a sliding pair to cross-shaped slider *5* which has guides perpendicular to each other. Slider *5* moves along fixed guides $t$-$t$ whose axis is parallel to axis $Oy$. Slider *5* is connected by turning pair $A$ to slider *2*. When link *1* turns about axis $O$, point $B$ describes parabola $q$-$q$, and points $E$ and $F$ describe branches $s$-$s$ and $s'$-$s'$ of the conchoid of parabola $q$-$q$. The equation of the conchoid is

$$(y^2 + x^2)(y^2 - 2px)^2 = d^2y^4.$$

1155

# LINK-GEAR MECHANISM FOR TRACING CONCHOIDS OF HYPERBOLAS

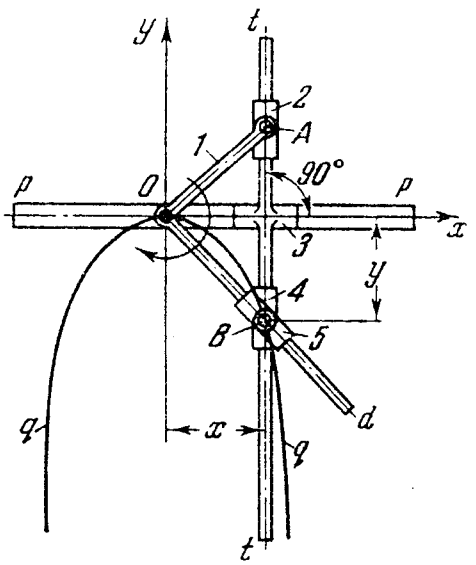
LG
Ge




The lengths of the links comply with the conditions: $\overline{AC} = \overline{GD}$, $\overline{CD} = \overline{AG} = 2c = 2\sqrt{a^2 + b^2}$, $\overline{BE} = \overline{BF} = d$ and $\overline{AO} = c - a$, where $a$ and $b$ are the transverse and conjugate semi-axes of the hyperbola and $c$ is the distance between its foci. Figure $ACDG$ is a crossed-crank linkage. Link *1*, turning about fixed axis $A$, is connected by turning pair $C$ to link *6* and by a sliding pair to slider *7*. Link *6* is connected by turning pair $D$ to link *5* which turns about fixed axis $G$. Link *5* is connected by a sliding pair to slider *4* which, in turn, is connected by turning pair $B$ to slider *7*. Link *2* is connected by turning pair $B$ to sliders *4* and *7*, and by a sliding pair to slider *3* which turns about fixed axis $O$. When link *1* turns about axis $A$, point $B$ describes branch $q$-$q$ of a hyperbola, and points $E$ and $F$ describe the branches of conchoid $p$-$p$ of hyperbola $q$-$q$. The equation of the conchoid is

$$(y^2 + x^2)(b^2x^2 - a^2y^2 - 2ab^2x) = d^2(b^2x^2 - a^2y^2).$$

| 1156 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING KAPPA CURVES | LG Ge |
|---|---|---|

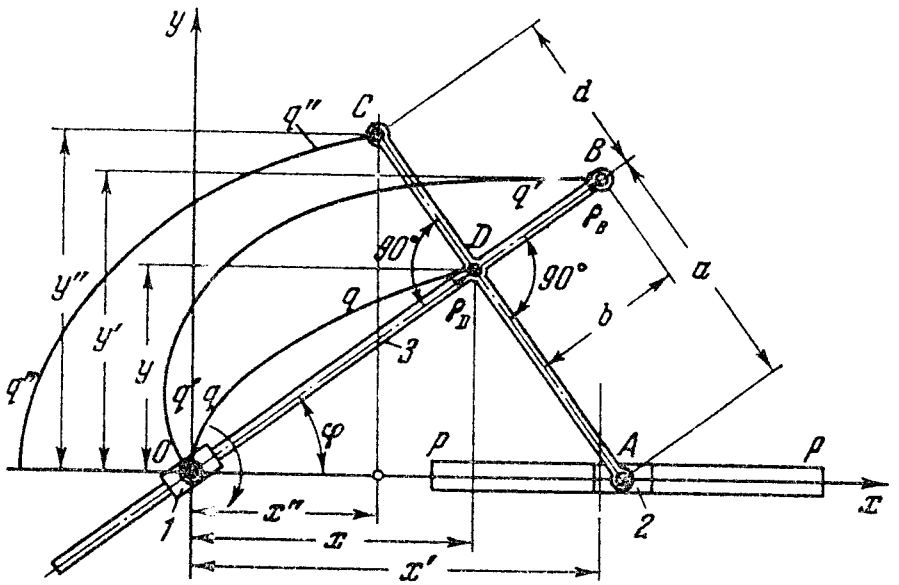



Link *1*, having the form of a bent liver with angle *AOd* equal to 90°, turns about fixed axis *O*. Link *1* is connected by turning pair *A* to slider *2* which moves along cross-piece *t-t* of slider *3*. Slider *3* moves along fixed guides *p-p* whose axis coincides with axis *Ox*. Arm *Od* of link *1* moves in slider *5* which is connected by turning pair *B* to slider *4*. Slider *4* moves along cross-piece *t-t* of slider *3*. When link *1* turns about axis *O*, point *B* describes a Kappa curve with the equation

$$y^2 = \frac{x^4}{a^2 - x^2}$$

where $a = \overline{OA}$.

| 1157 | LEBEAU LINK-GEAR MECHANISM FOR TRACING KAPPA CURVES | LG Ge |
|---|---|---|




Slider *1* turns about fixed axis *O*. Link *3*, having the form of a cross-shaped lever, is connected by a sliding pair to slider *1* and by turning pair *A* to slider *2*. Slider *2* moves along fixed guides *p-p* whose axis coincides with axis *Ox*. When slider *1* turns about axis *O*, point *D* of link *3* describes Kappa curve *q-q* with the equation

$$\rho_D = \overline{OD} = \frac{a}{\tan\varphi} \quad \text{or} \quad a^2x^2 = y^2(x^2+y^2).$$

Point *B* of link *3* describes conchoid *q'-q'* of the Kappa curve; the equation of the conchoid is

$$\rho_B = \overline{OB} = \frac{a}{\tan\varphi} \pm b \quad \text{or} \quad (ax'+by')^2 = y'^2(x'^2+y'^2).$$

Point *C* of link *3* describes orthoconchoid *q''-q''* of the Kappa curve; the equation of the orthoconchoid is

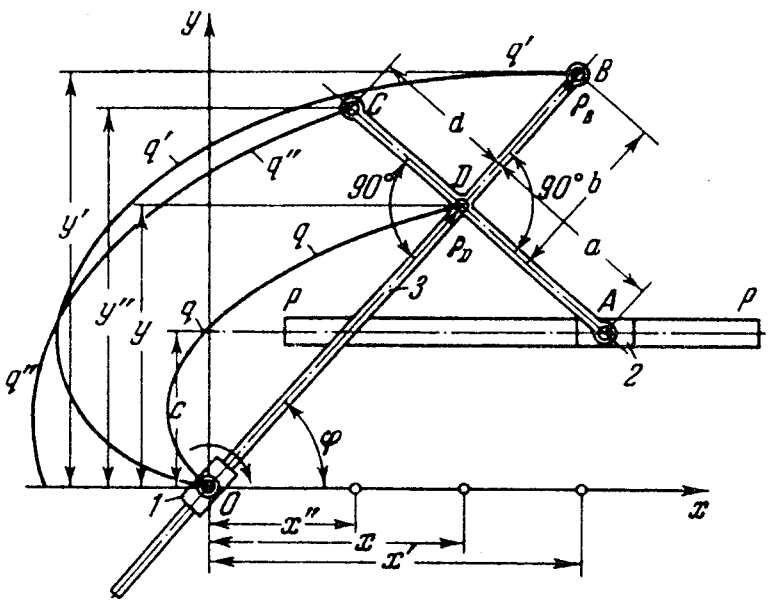
$$\rho_C = \overline{OC} = \sqrt{\frac{a^2}{\tan^2\varphi} + d^2}$$

or

$$x''^2[(a+d)^2 - y''^2] = [y''^2 - d(a+d)]^2$$

where $a$, $b$ and $d$ = constant dimensions of the mechanism
$\varphi$ = polar angle between vector $\rho_D$ and polar axis *Ox*.

| 1158 | LEBEAU LINK-GEAR MECHANISM FOR TRACING PANKAPPA CURVES | LG Ge |
|---|---|---|




Slider *1* turns about fixed axis *O*. Link *3*, having the form of a cross-shaped lever, is connected by a sliding pair to slider *1* and by turning pair *A* to slider *2*. Slider *2* moves along fixed guides *p-p* whose axis is parallel to axis *Ox*. When slider *1* turns about axis *O*, point *D* of link *3* describes Pankappa curve *q-q* with the equation

$$\rho_D = \overline{OD} = \frac{c}{\sin\varphi} + \frac{a}{\tan\varphi} \quad \text{or} \quad a^2x^2 - (y-c)^2(x^2+y^2).$$

Point *B* of link *3* describes conchoid *q'-q'* of the Pankappa curve; the equation of the conchoid is

$$\rho_B = \overline{OB} = \frac{c}{\sin\varphi} + \frac{a}{\tan\varphi} \pm b$$

or

$$(ax' + by')^2 = (y' - c)^2 (x'^2 + y'^2).$$

Point *C* of link *3* describes orthoconchoid *q''-q''* of the Pankappa curve; the equation of the orthoconchoid is

$$\rho_C = \overline{OC} = \sqrt{\left(\frac{c}{\sin\varphi} + \frac{a}{\tan\varphi}\right)^2 + d^2}$$

or

$$x^2[(y'' + d)^2 - (y'' - c)^2] = [(y' - c) - d(\quad)]^2$$

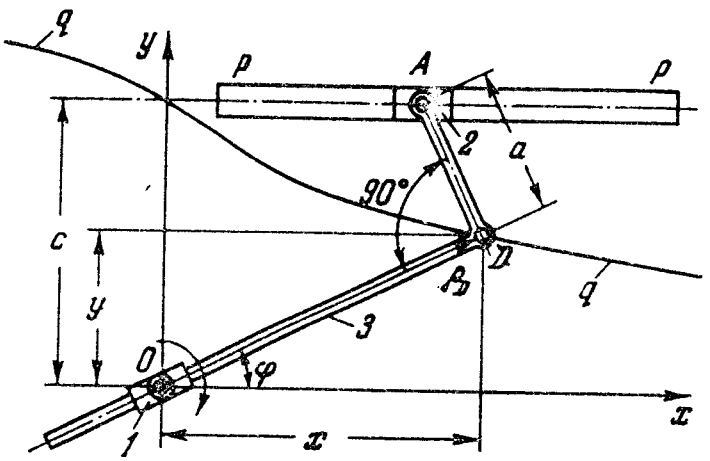
where $a$, $b$, $c$ and $d$ = constant dimensions of the mechanism, complying with the condition $c < a$

$\varphi$ = polar angle between vector $\rho_D$ and polar axis $Ox$.

1159

# LEBEAU LINK-GEAR MECHANISM FOR TRACING PANKAPPA CURVES

LG Ge




Slider *1* turns about fixed axis *O*. Link *3* has the form of a bent lever. Link *3* is connected by a sliding pair to slider *1* and by turning pair *A* to slider *2* which moves along fixed guides *p-p* whose axis is parallel to axis *Ox*. When slider *1* turns about axis *O*, point *D* of link *3* describes Pankappa curve *q-q* with the equation

$$\rho_D = \overline{OD} = \frac{c - a\cos\varphi}{\sin\varphi}$$

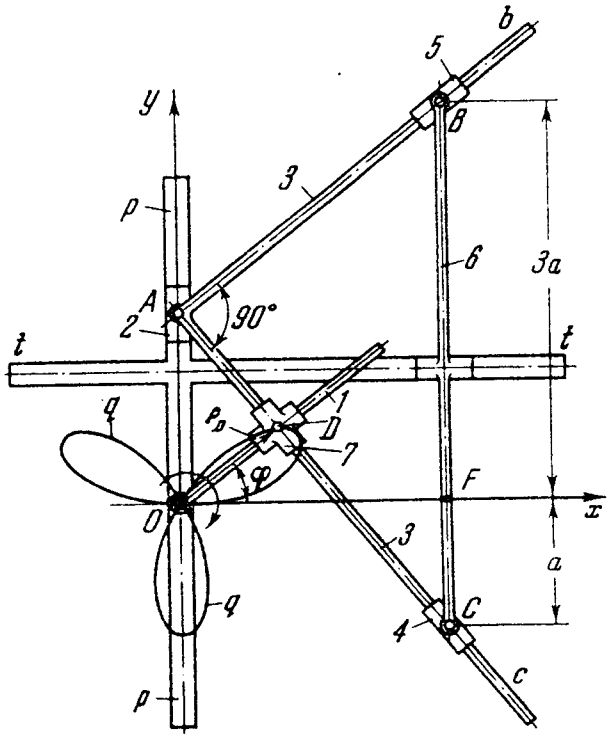
or

$$a^2x^2 = (c - y)^2 (x^2 + y^2)$$

where $a$ and $c$ = constant dimensions of the mechanism, complying with the condition $c > a$

$\varphi$ = polar angle between vector $\rho_D$ and polar axis *Ox*.

| 1160 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING THREE-LEAFED ROSES | LG Ge |
|---|---|---|



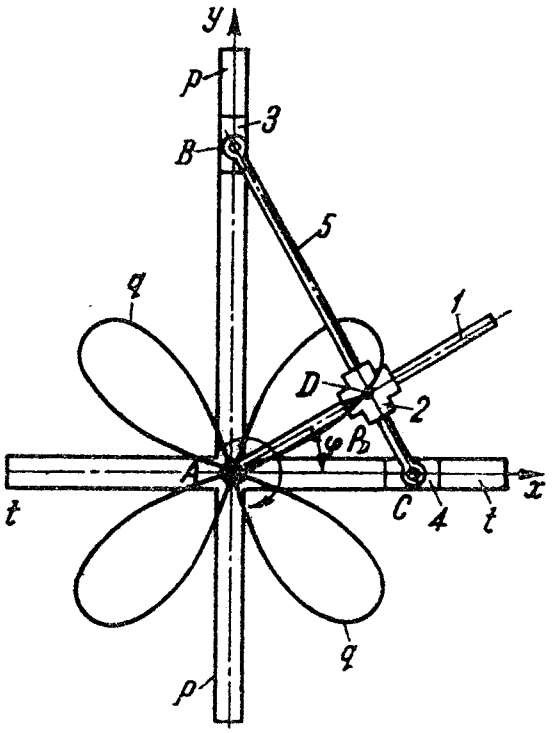

The lengths of the links comply with the conditions: $\overline{FC} = a$ and $\overline{BF} = 3a$. Link *1*, rotating about fixed axis *O*, is connected by a sliding pair to cross-shaped slider *7* which has guides perpendicular to each other. Link *3* has the form of a bent lever with angle *cAb* equal to 90°. Link *3* is connected by turning pair *A* to slider *2* which moves along fixed guides *p-p* whose axis coincides with axis *Oy*. Arm *Ab* of link *3* is connected by a sliding pair to slider *5*, and arm *Ac* by a sliding pair to slider *4*. Slider *6* moves along fixed guides *t-t* whose axis is parallel to axis *Ox*. Slider *6* is connected by turning pairs *B* and *C* to sliders *5* and *4*. When link *1* rotates about axis *O*, point *D* of slider *7* describes three-leafed rose *q-q* with the equation

$$\rho_D = \overline{OD} = a \sin 3\varphi$$

where φ is the [illegible] angle between vector $\rho_D$ and polar axis *Ox*.

## 1161 ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING FOUR-LEAFED ROSES





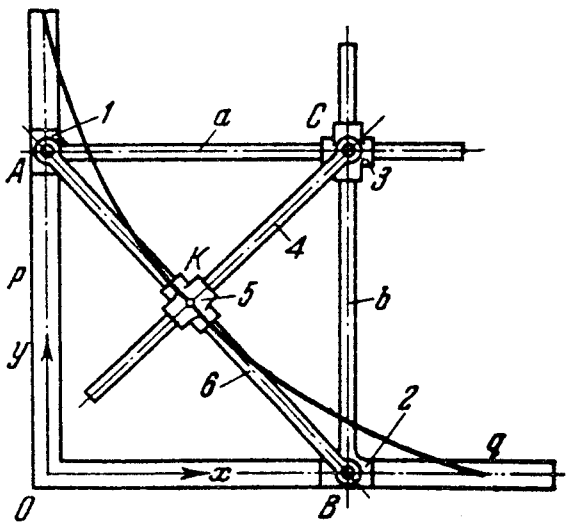

Link *1*, rotating about fixed axis *A*, is connected by a sliding pair to cross-shaped slider *2* which has guides perpendicular to each other. Link *5* is connected by a sliding pair to slider *2* and by turning pairs *B* and *C* to sliders *3* and *4*. Slider *3* moves along fixed guides *p-p* whose axis coincides with axis *Ay*, and slider *4* along fixed guides *t-t* whose axis coincides with axis *Ax*. When link *1* rotates about axis *A*, point *D* of slider *2* describes four-leafed rose *q-q* with the equation

$$\rho_D = \overline{AD} = a \sin 2\varphi$$

where $a = 0.5\overline{BC}$

$\varphi$ = polar angle between vector $\rho_D$ and polar axis *Ax*.

| 1162 | VYATKIN LINK-GEAR MECHANISM FOR TRACING ASTROIDS | LG Ge |
|---|---|---|



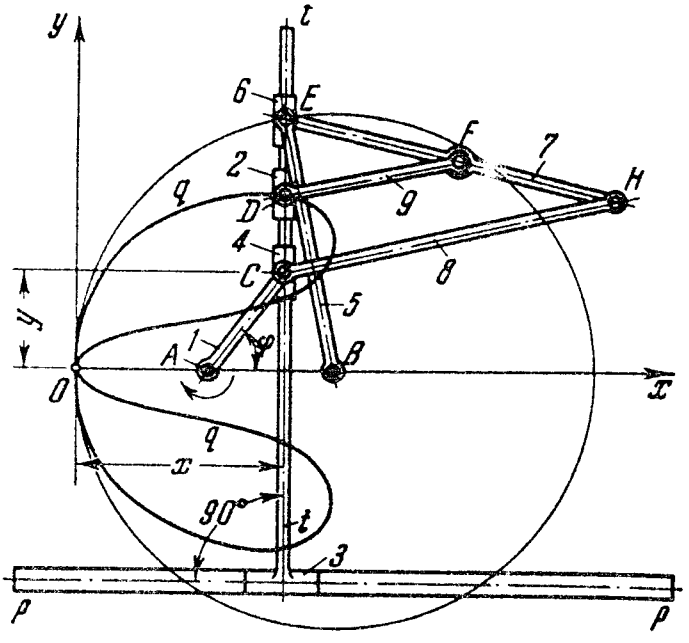

Sliders *1* and *2* move along fixed guides *p* and *q* whose axes are perpendicular to each other. Extensions *a* and *b* of sliders *1* and *2* move in cross-shaped slider *3* whose guides are perpendicular to each other. Link *4* is connected by turning pair *C* to slider *3* and moves in cross-shaped slider *5*. Slider *5* moves along the axis of link *6* which is connected by turning pairs *A* and *B* to sliders *1* and *2*. When sliders *1* and *2* move along guides *p* and *q*, point *K* of slider *5* describes an arc of an astroid with the equation

$$x^{2/3} + y^{2/3} = l^{2/3}$$

where $l = \overline{AB}$. At the same time, straight line *AB* envelops the astroid.

## 1163 ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING VIRTUAL PARABOLAS OF CRAMER

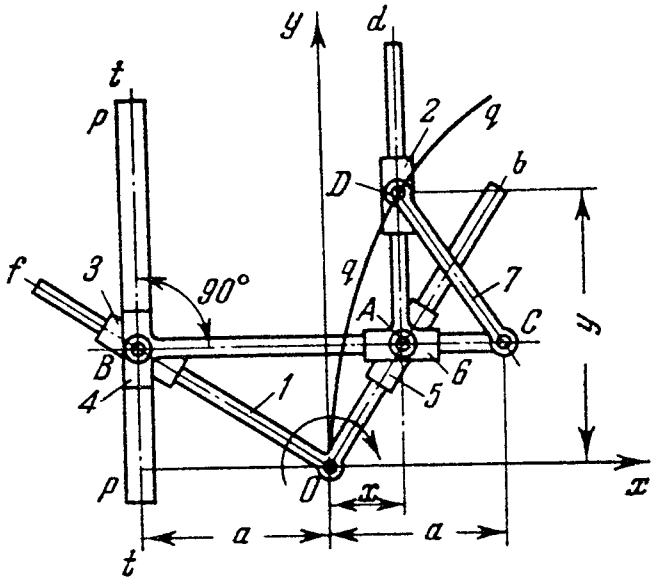





The lengths of the links comply with the conditions: $\overline{AC} = \overline{AB} = a$, $\overline{BE} = 2a$, and $\overline{CH} : \overline{DF} = \overline{HE} : \overline{FE} = 2$. Link *1*, rotating about fixed axis *A*, is connected by turning pair *C* to slider *4* which moves along cross-piece *t-t* of slider *3*. Slider *3* moves along fixed guides *p-p* whose axis is parallel to axis *Ox*. Link *8* is connected by turning pairs *C* and *H* to slider *4* and link *7*. Link *7* is connected by turning pairs *E* and *F* to slider *6* and link *9*. Link *9* is connected by turning pair *D* to slider *2* which moves along cross-piece *t-t* of slider *3*. Link *5*, rotating about fixed axis *B*, is connected by turning pair *E* to slider *6* which also moves along cross-piece *t-t* of slider *3*. When link *1* rotates about axis *A*, point *D* of slider *2* describes virtual parabola of Cramer *q-q* with the equation

$$2y = \sqrt{x(2a-x)} + \sqrt{x(4a-x)}.$$

| 1164 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING PARABOLAS OF CRAMER | LG, Ge |
|---|---|---|



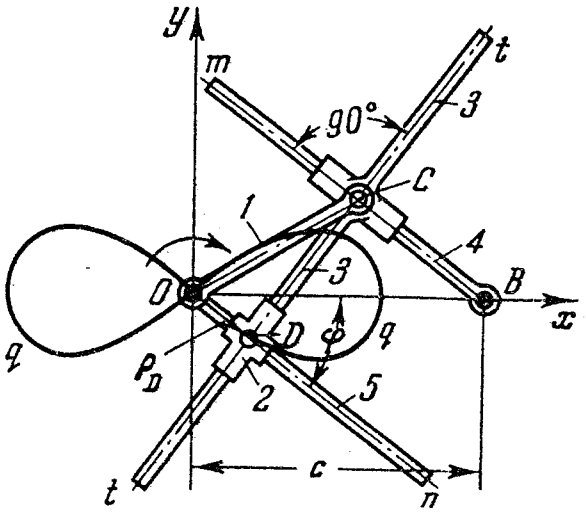

Link *1* has the form of a bent lever with the angle *fOb* equal to 90°. Link *1* turns about fixed axis *O*. Arm *Of* of link *1* moves in slider *3* and arm *Ob* in slider *5*. Slider *3* is connected by turning pair *B* to slider *4* which moves along fixed guides *p-p* whose axis *t-t* is parallel to axis *Oy*. Cross-piece *BC* of slider *4*, is connected by turning pair *C* to link *7* which, in turn, is connected by turning pair *D* to slider *2*. Slider *2* moves along cross-piece *Ad* of slider *6*. Axis *Ad* is parallel to axis *Oy*. Sliders *5* and *6* are connected together by turning pair *A*. When link *1* turns about axis *O*, point *D* of slider *2* describes parabola of Cramer *q-q* with the equation

$$y=\sqrt{ax}-\sqrt{2ax-x^2}$$

where $a$ is a constant dimension of the mechanism.

1165 **ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING PEDAL CURVES OF HYPERBOLAS**

LG Ge



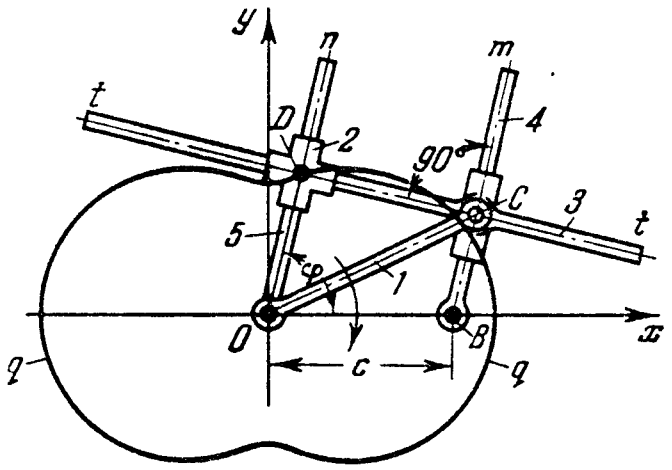

The lengths of the links comply with the conditions: $\overline{OC} = a$, $\overline{OB} = c = \sqrt{a^2 + b^2}$ and $a < c$, where $a$ and $b$ are the transverse and conjugate semiaxes of the hyperbola. Link *1* turns about fixed axis *O* and is connected by turning pair *C* to slider *3*. Slider *3* moves along axis *Bm* of link *4* which turns about fixed axis *B*. Cross-piece *t-t* of slider *3* is connected by a sliding pair to cross-shaped slider *2* which has guides perpendicular to each other. Slider *2* moves along axis *On* of link *5* which rotates about axis *O*. Centre *O* is placed at the centre of the hyperbola and centre *B* at one of its foci. Then, when link *1* turns about axis *O*, point *D* of slider *2* describes pedal curve *q-q* of the hyperbola. The equation of the pedal curve is

$$\rho_D = \overline{OD} = \sqrt{a^2 - c^2 \sin^2 \varphi} \quad \text{or} \quad (x^2 + y^2)^2 = a^2 x^2 - b^2 y^2$$

where $\varphi$ is the polar angle between vector $\boldsymbol{\rho}_D$ and polar axis *Ox*. If the lengths of the links comply with the condition $c = \sqrt{2}a$, then point *D* describes a lemniscate of Bernoulli with the equation

$$\rho_D = \overline{OD} = a\sqrt{2\cos^2 \varphi} \quad \text{or} \quad (x^2 + y^2)^2 = 4a^2 (x^2 - y^2).$$

| 1166 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING PEDAL CURVES OF ELLIPSES | LG Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{OC} = a$, $\overline{OB} = c = \sqrt{a^2 - b^2}$ and $a > c$, where $a$ and $b$ are the semi-axes of the ellipse. Link *1* turns about fixed axis *O* and is connected by turning pair *C* to slider *3*. Slider *3* moves along axis *Bm* of link *4* which turns about fixed axis *B*. Cross-piece *t-t* of slider *3* is connected by a sliding pair to cross-shaped slider *2* which has guides perpendicular to each other. Slider *2* moves along axis *On* of link *5* which rotates about axis *O*. Centre *O* is placed at the centre of the ellipse and centre *B* at one of its foci. Then, when link *1* turns about axis *O*, point *D* of slider *2* describes pedal curve *q-q* of the ellipse. The equation of the pedal curve is

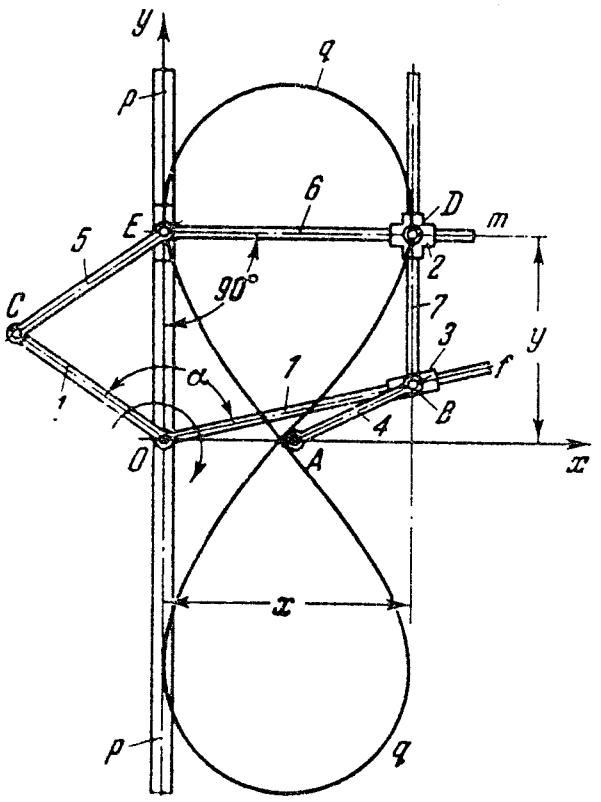
$$\rho_D = \overline{OD} = \sqrt{a^2 - c^2 \sin^2 \varphi}$$

or

$$(x^2 + y^2)^2 = a^2x^2 + b^2y^2$$

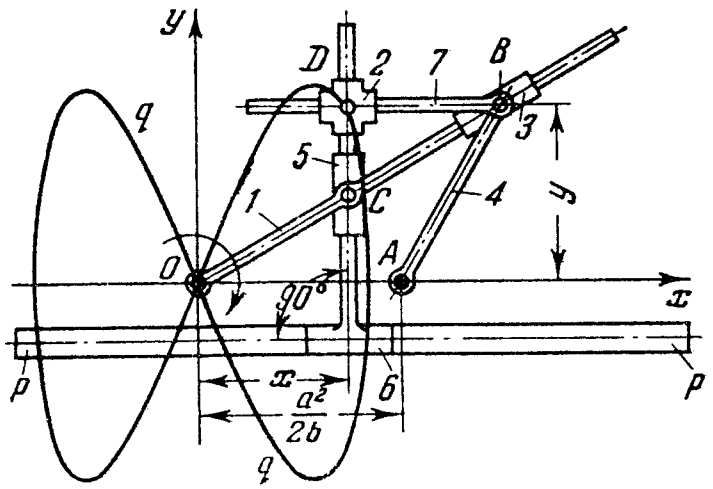
where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis *Ox*.

| 1167 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING VIRTUAL PARABOLAS OF VINCENTIO | LG Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AB} = \overline{OA} = a$, $\overline{OC} = \overline{CE} = d$ and $\tan\alpha = b/a$, where $\alpha$ is fixed angle $COf$ and $b = \sqrt{d^2 - a^2}$. Link *1* has the form of a bent lever with angle $COf$ equal to $\alpha$. Link *1* turns about fixed axis *O* and is connected by turning pair *C* to link *5* and by a sliding pair to slider *3*. Slider *3* is connected by turning pair *B* to link *4* which turns about fixed axis *A*. Slider *3* is also connected by turning pair *B* to link *7* which moves in cross-shaped slider *2* whose guides are perpendicular to each other. Link *5* is connected by turning pair *E* to slider *6* which moves along fixed guides *p-p* whose axis coincides with axis *Oy*. When link *1* turns about point *O*, point *D* of slider *2* describes virtual parabola of Vincentio *q-q* with the equation

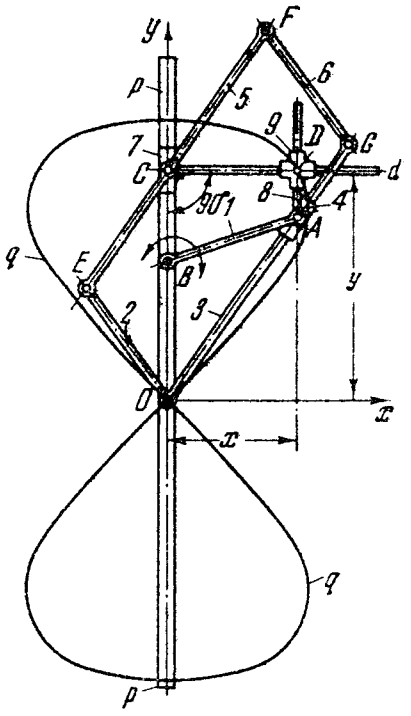
$$y = \sqrt{2ax} - \sqrt{4b^2 - \frac{2b^2}{a}x}.$$




The lengths of the links comply with the conditions: $\overline{OC} = a$ and $\overline{OA} = \overline{AB} = a^2/2b$, where $b$ is an arbitrary constant. Link *1* rotates about fixed axis *O*. Link *1* is connected by turning pair *C* to slider *5* and by a sliding pair to slider *3*. Link *4*, turning about fixed axis *A*, is connected by turning pair *B* to slider *3*. Slider *5* moves along the cross-piece of slider *6* which moves along fixed guides *p-p* whose axis is parallel to axis *Ox*. Link *7* is connected by turning pair *B* to slider *3* and by a sliding pair to cross-shaped slider *2* which has guides perpendicular to each other. Slider *2* moves along the cross-piece of slider *6*. When link *1* rotates about axis *O*, point *D* of slider *2* describes lemniscate of Sluze *q-q* with the equation

$$(a^2 - x^2)\, x^2 = b^2 y^2.$$

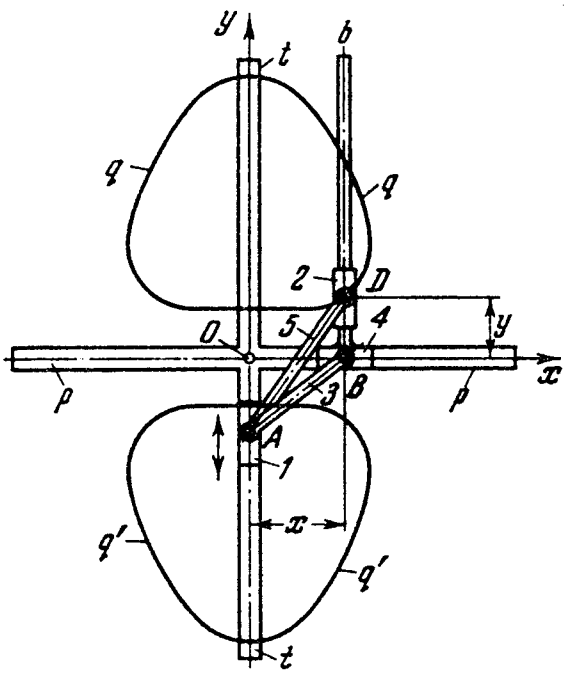
| 1169 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING LEMNISCATES OF GERONO | LG Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{EF} = \overline{OG}$, $\overline{OE} = \overline{EC} = \overline{FC} = \overline{BA} = \overline{OB} = a/2$. Figure *EFGO* is a parallel-crank linkage. Link *1* turns about fixed axis *B* and is connected by turning pair *A* to slider *4*. Slider *4* moves along the axis of link *3* which turns about fixed axis *O*. Link *5* is connected by turning pairs *E*, *F* and *C* to links *2* and *6* and to slider *7* which moves along fixed guides *p-p* whose axis coincides with axis *Oy*. Link *2* turns about axis *O*. Link *6* is connected by turning pair *G* to link *3*. Link *8* is connected by turning pair *A* to slider *4* and moves in cross-shaped slider *9* which has guides perpendicular to each other. Slider *9* moves along cross-piece *Cd* of slider *7*. When link *1* turns about axis *B*, point *D* of slider *9* describes lemniscate of Gerono *q-q* (eight curve) with the equation

$$y^4 = a^4 (y^2 - x^2).$$

| 1170 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING POLYZOMAL CURVES OF BERNOULLI | LG Ge |
|---|---|---|

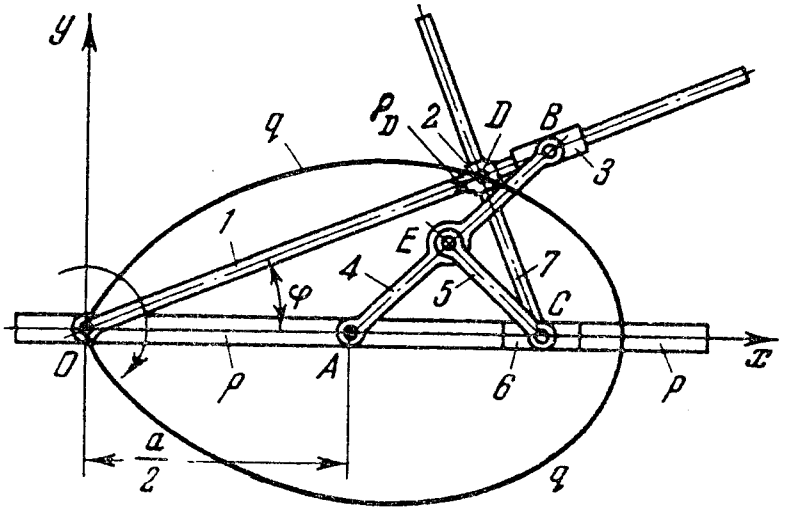



The lengths of the links comply with the conditions: $\overline{AD} = a\sqrt{2}$ and $\overline{AB} = a$. Slider *1* moves along fixed guides *t-t* whose axis coincides with axis *Oy*. Slider *1* is connected by turning pair *A* to links *3* and *5*. Link *3* is connected by turning pair *B* to slider *4* which moves along fixed guides *p-p* whose axis coincides with axis *Ox*. Link *5* is connected by turning pair *D* to slider *2* which moves along cross-piece *Bb* of slider *4*. The axis of cross-piece *Bb* is parallel to axis *Oy*. When slider *1* moves along guides *t-t*, point *D* of slider *2* describes the upper branch *q-q* of a polyzomal curve of Bernoulli with the equation

$$y = \sqrt{2a^2 - x^2} + \sqrt{a^2 - x^2}.$$

To trace the lower branch *q'-q'* of this curve, the links of the mechanism are reassembled symmetric to the axis *Ox*.

| 1171 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING SIMPLE RIGHT FOLIA | LG Ge |
|---|---|---|

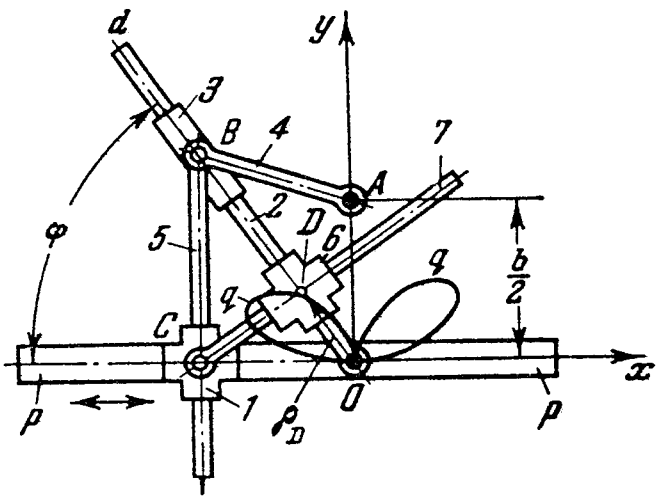



The lengths of the links comply with the conditions: $\overline{AB} = \overline{OA} = a/2$ and $\overline{AE} = \overline{EB} = \overline{EC} = a/4$. Link *1* turns about fixed axis *O* and is connected by sliding pairs to slider *3* and to cross-shaped slider *2* which has guides perpendicular to each other. Link *4* turns about fixed axis *A* and is connected by turning pairs *E* and *B* to link *5* and slider *3*. Links *5* and *7* are connected by turning pairs *C* to slider *6* which moves along fixed guides *p-p* whose axis coincides with axis *Ox*. When link *1* turns about axis *O*, point *D* of slider *2* describes simple right folium *q-q* with the equation

$$\rho_D = \overline{OD} = a \cos^3 \varphi \text{ or } (x^2 + y^2)^2 = ax^3$$

where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis *Ox*.

| 1172 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING DOUBLE RIGHT FOLIA | LG Ge |
|---|---|---|



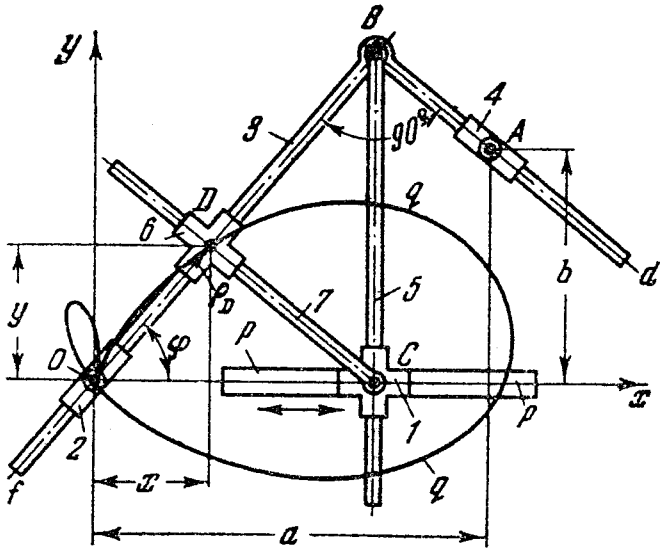

The lengths of the links comply with the condition: $\overline{AB} = \overline{AO} = b/2$. Cross-shaped slider *1*, with guides perpendicular to each other, moves along fixed guides *p-p*. Link *5* is connected by a sliding pair to slider *1* and by turning pair *B* to slider *3*. Slider *3* moves along axis *Od* of link *2* which turns about fixed axis *O*. Link *7* is connected by turning pair *C* to slider *1* and by a sliding pair to cross-shaped slider *6* which has guides perpendicular to each other. Link *4* turns about fixed axis *A* and is connected by turning pair *B* to slider *3*. When slider *1* moves along guides *p-p*, point *D* of slider *6* describes double right folium *q-q* with the equation

$$\rho_D = \overline{OD} = b \sin\varphi \cos^2\varphi \text{ or } (x^2 + y^2)^2 = bx^2y$$

where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis *Ox*.

## 1173 ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING OBLIQUE DOUBLE FOLIA






Cross-shaped slider *1*, with guides perpendicular to each other, moves along fixed guides *p-p* and is connected by turning pair *C* to link *7*. Link *7* moves in cross-shaped slider *6* which has guides perpendicular to each other. Link *3* has the form of a bent lever. Arm *Bd* of link *3* moves in slider *4* which turns about fixed axis *A*. Arm *Bf* of link *3* moves in slider *6* and in slider *2* which turns about fixed axis *O*. Link *5* is connected by turning pair *B* to link *3* and moves in slider *1*. When slider *1* moves along guides *p-p*, point *D* describes oblique double folium *q-q* with the equation

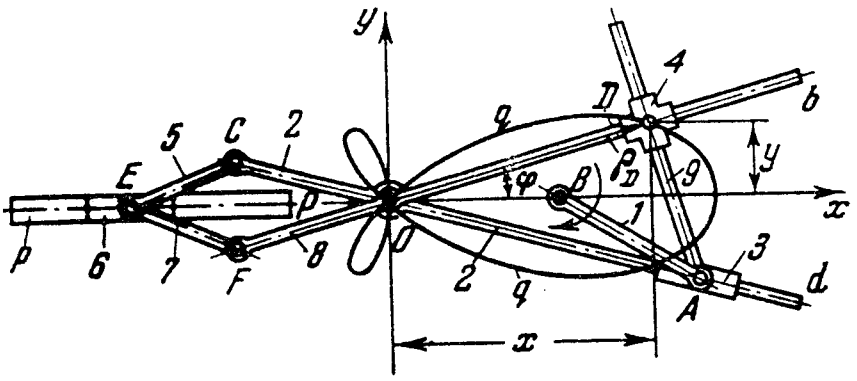
$$\rho_D = \overline{OD} = a \cos^3 \varphi + b \sin \varphi \cos^2 \varphi$$

or

$$(x^2 + y^2)^2 = x^2 (ax + by)$$

where $a$ and $b$ = constant dimensions of the mechanism
$\varphi$ = polar angle between vector $\rho_D$ and polar axis $Ox$.

| 1174 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING TRIPLE RIGHT FOLIA | LG Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AB} = \overline{OB} = a$, $\overline{OC} = \overline{OF}$ and $\overline{CE} = \overline{FE}$. Figure $ECOF$ is a rhombus linkage. Link *1* turns about fixed axis $B$ and is connected by turning pairs $A$ to link *9* and slider *3* which moves along axis $Od$ of link *2*. Link *2* turns about fixed axis $O$. Link *9* is connected by a sliding pair to cross-shaped slider *4* which has guides perpendicular to each other. Slider *4* moves along axis $Ob$ of link *8* which turns about axis $O$ and is connected by turning pair $F$ to link *7*. Link *5* is connected by turning pair $C$ to link *2*. Links *5* and *7* are connected by turning pairs $E$ to slider *6* which moves along fixed guides $p$-$p$ whose axis coincides with axis $Ox$. When link *1* turns about axis $B$, point $D$ of slider *4* describes triple right folium $q$-$q$ with the equation

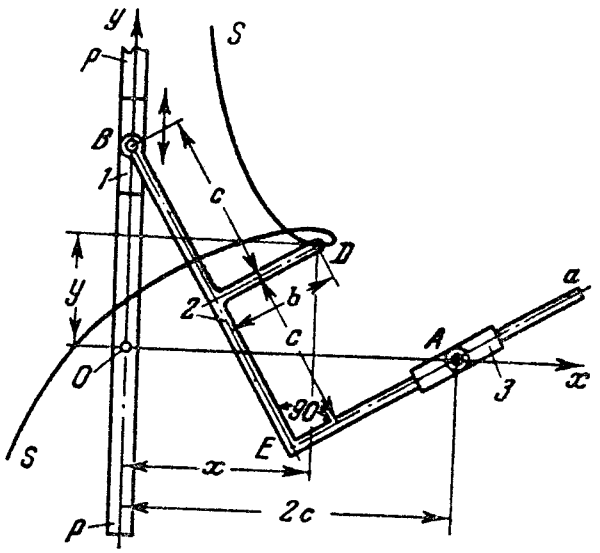
$$\rho_D = \overline{OD} = 2a \cos\varphi \sin^2\varphi$$

or

$$(x^2 + y^2)^2 = 2ax\,(x^2 - y^2)$$

where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis $Ox$.

| 1175 | LINK-GEAR MECHANISM FOR TRACING OPHIURIDES | LG Ge |
|---|---|---|

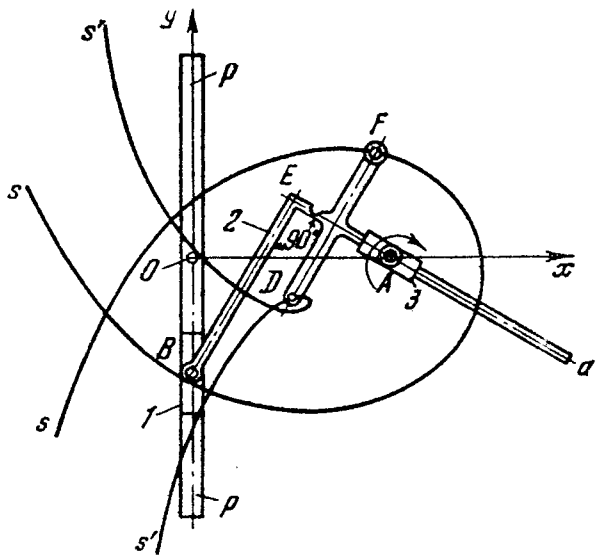



Slider *1* moves along fixed guides *p-p* and is connected by turning pair *B* to link *2* which has the form of a bent lever with angle *BEa* equal to 90°. Arm *Ea* of link *2* is connected by a sliding pair to slider *3* which turns about fixed axis *A*. When slider *1* moves along guides *p-p*, point *D* of link *2* describes ophiuride *s-s* with the equation

$$(c - x)^3 = (b + y)\,(3bc + cy - bx + yx)$$

where *b* and *c* are constant dimensions of the mechanism.

| 1176 | POLYNOVSKY LINK-GEAR MECHANISM FOR TRACING FOCAL-TYPE CURVES | LG Ge |
|---|---|---|

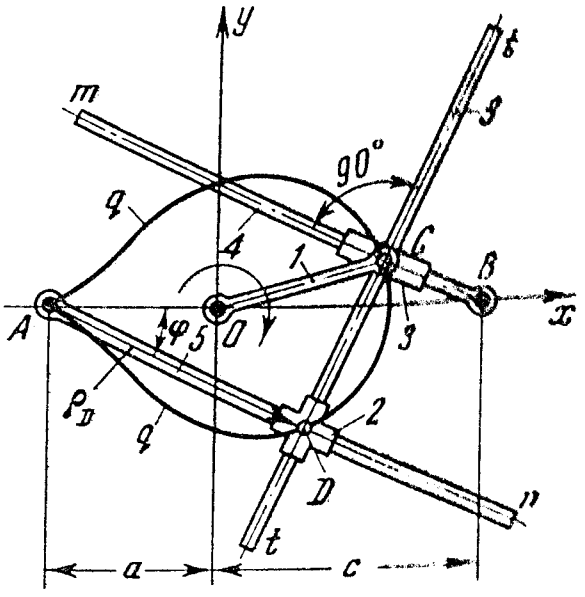



The lengths of the links comply with the conditions: $BE = \overline{OA} = d$ and $\angle BEa = 90°$. Slider *1* moves along fixed guides *p-p* and is connected by turning pair *B* to link *2*. Arm *Ea* of link *2* moves in slider *3* which turns about fixed axis *A*. When slider *3* turns about axis *A*, point *F* of link *2* describes a third-order focal-type curve. Curves *s-s* and *s'-s'*, described by points *F* and *D*, are shown as examples. If points *F* and *D* lie on straight line *BE* they describe a conchoid and a strophoid with the equation

$$y^2 = \frac{a \pm c - x}{a \pm c + x}(c - x)^2$$

where $a = \overline{OA}$

$c =$ distance from points *F* and *D* to straight line *Ea*.



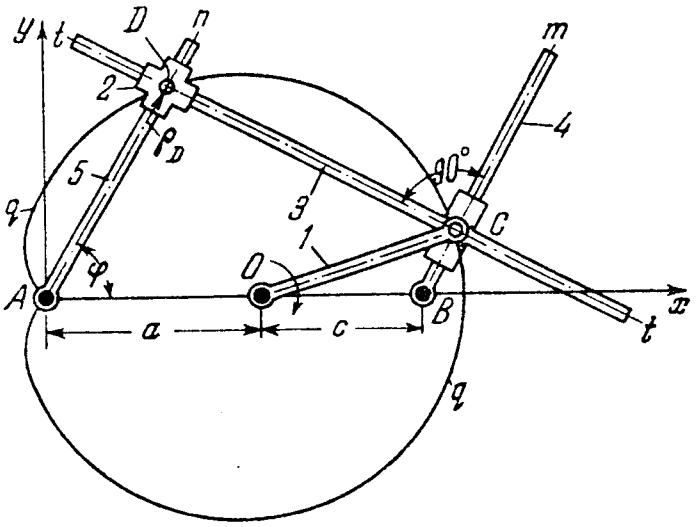

The lengths of the links comply with the conditions: $\overline{OC} = \overline{OA} = a$, $\overline{OB} = c = \sqrt{a^2 + b^2}$ and $a < c$, where $a$ and $b$ are the transverse and conjugate semiaxes of the hyperbola. Link *1* turns about fixed axis *O* and is connected by turning pair *C* to slider *3*. Slider *3* moves along axis *Bm* of link *4* which turns about fixed axis *B*. Cross-piece *t-t* of slider *3* is connected by a sliding pair to cross-shaped slider *2* which has guides perpendicular to each other. Slider *2* moves along axis *An* of link *5* which turns about fixed axis *A*. Centre *O* is placed at the centre of the hyperbola and centre *B* at one of its foci. Then, when link *1* turns about axis *O*, point *D* of slider *2* describes pedal curve *q-q* of the hyperbola with respect to one of its vertices. The equation of pedal curve *q-q* is

$$\rho_D = \overline{OD} = a\cos\varphi + \sqrt{a^2 - c^2\sin^2\varphi}$$

or

$$(x^2 + y^2)^2 + 2(x^2 + y^2)\,ax = b^2y^2$$

where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis $Ax$.




The lengths of the links comply with the conditions: $\overline{OC} = \overline{OA} = a$, $\overline{OB} = c = \sqrt{a^2 - b^2}$ and $a > c$, where $a$ and $b$ are the semiaxes of the ellipse. Link *1* turns about fixed axis *O* and is connected by turning pair *C* to slider *3*. Slider *3* moves along axis *Bm* of link *4* which turns about fixed axis *B*. Cross-piece *t-t* of slider *3* is connected by a sliding pair to cross-shaped slider *2* which has guides perpendicular to each other. Slider *2* moves along axis *An* of link *5* which turns about fixed axis *A*. Centre *O* is placed at the centre of the ellipse and centre *B* at one of its foci. Then, when link *1* turns about axis *O*, point *D* of slider *2* describes pedal curve *q-q* of the ellipse with respect to one of its vertices. The equation of pedal curve *q-q* is

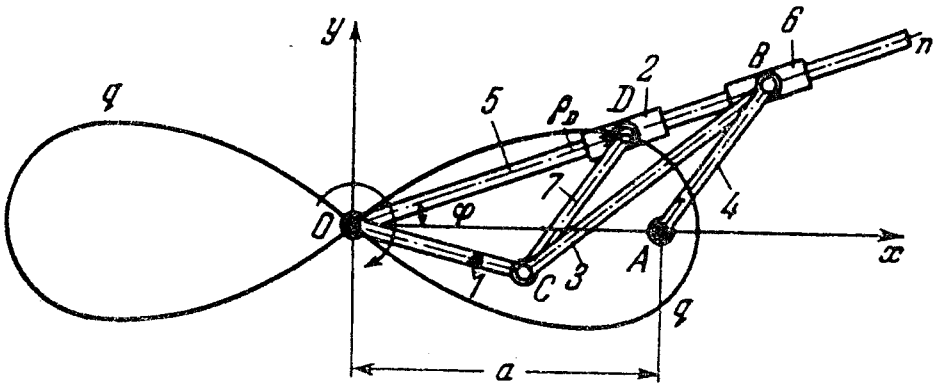
$$\rho_D = \overline{OD} = a\cos\varphi + \sqrt{a^2 - c^2\sin^2\varphi}$$

or

$$(x^2 + y^2)^2 - 2(x^2 + y^2)ax = b^2y^2$$

where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis $Ox$.

| 1179 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING HYPERBOLIC LEMNISCATES OF BOUTH | LG Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{OA} = \overline{BC} = a$, $\overline{OC} = \overline{AB} = \overline{CD} = b$ and $b < a$. Figure $OABC$ is a crossed-crank linkage. Link *1* turns about fixed axis $O$ and is connected by turning pairs $C$ to links *3* and *7*. Links *3* and *7* are connected by turning pairs $B$ and $D$ to sliders *6* and *2* which move along axis $On$ of link *5*. Link *5* turns about fixed axis $O$. When link *1* turns about axis $O$, point $D$ of slider *2* describes hyperbolic lemniscate of Bouth $q$-$q$ with the equation

$$\rho_D = \overline{OD} = 2\sqrt{b^2 - a^2 \sin^2 \varphi}$$

or

$$(x^2 + y^2)^2 = d^2x^2 - f^2y^2$$

where $d^2 = 4b^2$

$f^2 = 4(b^2 - a^2)$

$\varphi$ = polar angle between vector $\rho_D$ and polar axis $Ox$.

If the lengths of the links also comply with the condition $a = b\sqrt{2}$, then point $D$ describes a lemniscate of Bernoulli.

| 1180 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING ELLIPTIC LEMNISCATES OF BOUTH | LG Ge |
|---|---|---|

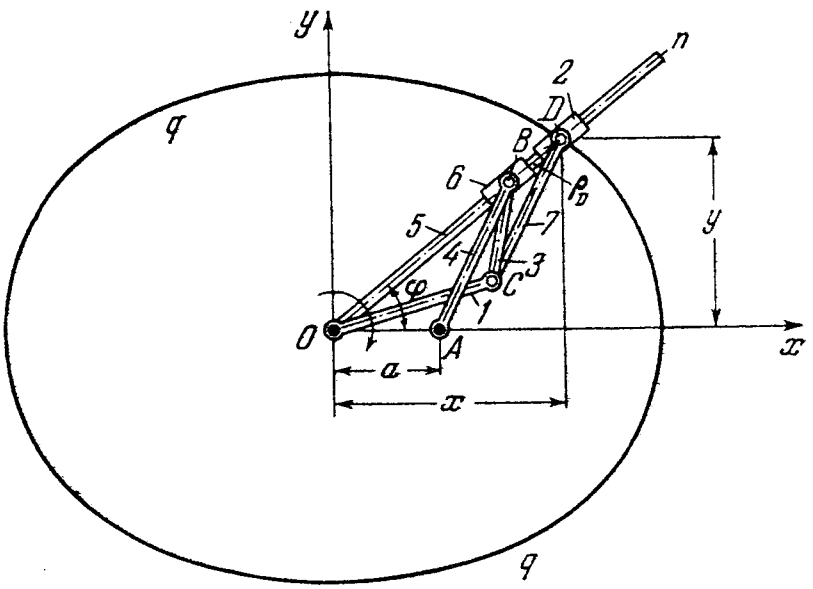



Figure $OABC$ is a crossed-crank linkage. Link *1* turns about fixed axis $O$ and is connected by turning pairs $C$ to links *3* and *7*. Links *3* and *7* are connected by turning pairs $B$ and $D$ to sliders *6* and *2* which move along axis $On$ of link *5*. Link *5* turns about axis $O$. Link *4* turns about fixed axis $A$ and is connected by turning pair $B$ to slider *6*. When link *1* turns about axis $O$, point $D$ of slider *2* describes elliptic lemniscate $q$-$q$ with the equation

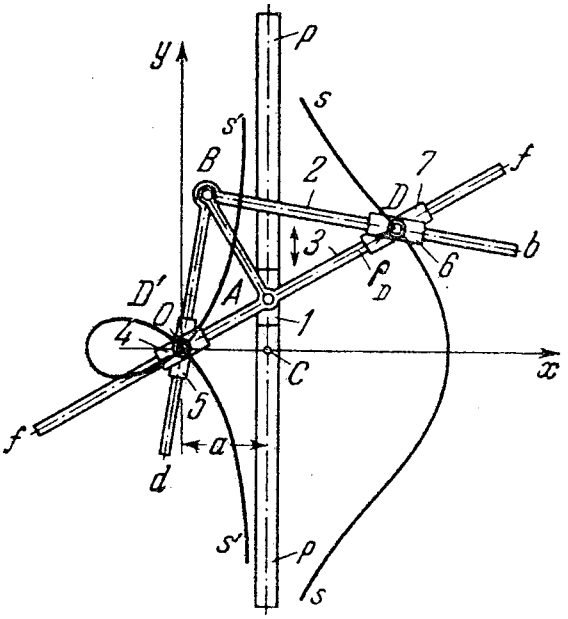
$$\rho_D = \overline{OD} = a\sqrt{b^2 - a^2 \sin^2 \varphi}$$

or

$$(x^2 + y^2)^2 = d^2x^2 + f^2y^2$$

where $d^2 = 4b^2$
$f^2 = 4\,(b^2 - a^2)$
$\varphi$ = polar angle between vector $\rho_D$ and polar axis $Ox$.

| 1181 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING CONCHOIDS OF SLUZE | LG Ge |
|---|---|---|




Slider *1* moves along fixed guides *p-p* and is connected by turning pair *A* to link *3*. Cross-piece *f-f* of link *3* moves in sliders *4* and *7*. Slider *4* turns about fixed axis *O* and is connected by a turning pair to slider *5* which also turns about axis *O*. Link *2* has the form of a bent lever with angle *dBb* equal to 90° and is connected by turning pair *B* to link *3*. Arm *Bb* of link *2* moves in slider *6* and arm *Bd* in slider *5*. Sliders *6* and *7* are connected together by turning pair *D*. When slider *1* moves along guides *p-p*, point *D* of slider *7* describes the right branch *s-s* of a conchoid of Sluze. Point *D'*, located on cross-piece *f-f* of link *3* at the distance $\overline{AD'} = \overline{AD}$, describes the left branch *s'-s'* of the conchoid. To trace conchoid *s'-s'* it is necessary to rearrange the mechanism or to add links that maintain the equality of distances $\overline{AD'}$ and $\overline{AD}$. The equation of the conchoid of Sluze is

$$\rho_D = \overline{OD} = \frac{a}{\cos\varphi} + \frac{k^2}{a}\cos\varphi$$

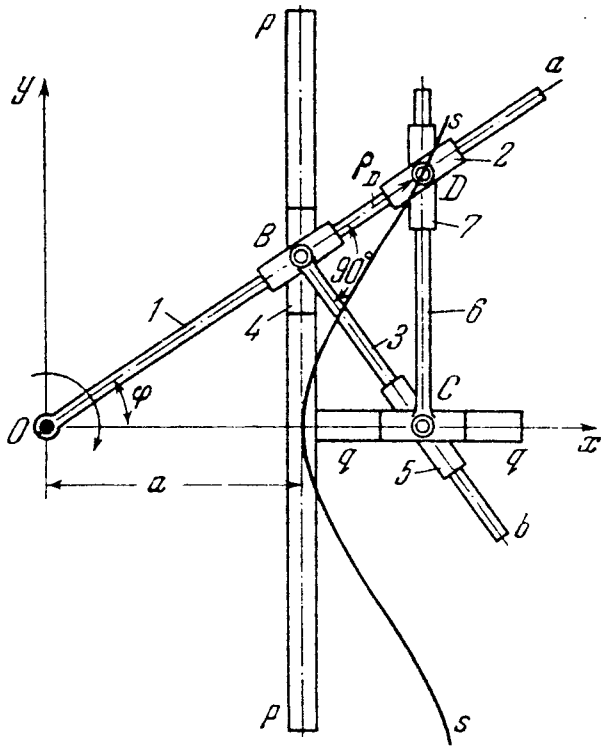
or

$$a\,(x^2 + y^2)\,(x - a) = \pm k^2 x^2$$

where $\varphi$ = polar angle between vector $\rho_D$ and polar axis $Ox$
$k = \overline{AB}$.

The plus sign corresponds to branch *s-s* and the minus sign to branch *s'-s'*.

| 1182 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING CUBIC DUPLICATRICES | LG Ge |
|---|---|---|

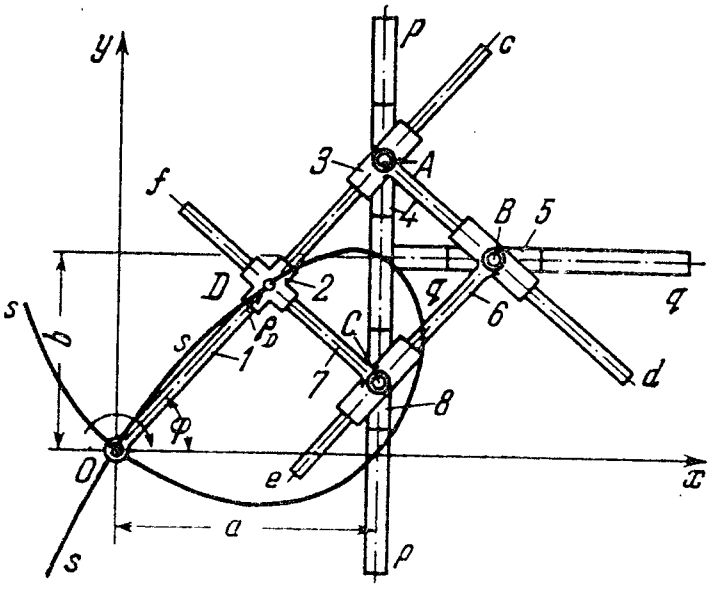



Link *1* turns about fixed axis *O* and is connected by sliding pairs to sliders *3* and *2*. Slider *3* is connected by turning pair *B* to slider *4* which moves along fixed guides *p-p* whose axis is perpendicular to axis *Ox*. Cross-piece *Bb* of slider *3* moves in slider *5*. Slider *5* is connected by turning pair *C* to slider *6* which moves along fixed guides *q-q*. Sliders *2* and *7* are connected together by turning pair *D*. When link *1* turns about axis *O*, point *D* of slider *7* describes cubic duplicatrix *s-s* with the equation

$$\rho_D = \overline{OD} = \frac{a}{\cos^3 \varphi} \quad \text{or} \quad y^2 = x^2 \frac{x-a}{a}$$

where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis *Ox*.

| 1183 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING OBLIQUE PARABOLIC FOLIA | LG Ge |
|---|---|---|




Link *1* turns about fixed axis *O* and is connected by sliding pairs to slider *3* and to cross-shaped slider *2* which has guides perpendicular to each other. Slider *3* is connected by turning pair *A* to slider *4* which moves along fixed guides *p-p* whose axis is perpendicular to axis *Ox*. Cross-piece *Ad* of slider *3* is connected by a sliding pair to slider *6*. Slider *6* is connected by turning pair *B* to slider *5* which moves along fixed guides *q-q* whose axis is perpendicular to axis *Oy*. Cross-piece *Be* of slider *6* is connected by a sliding pair to slider *7*. Slider *7* is connected by turning pair *C* to slider *8* which moves along guides *p-p*. Cross-piece *Cf* of slider *7* is connected by a sliding pair to slider *2*. Since axes *Oc*, *Ad*, *Be* and *Cf* are perpendicular to each other in this order, figure *DABC* is always a rectangle. When link *1* turns about axis *O*, point *D* of slider *2* describes oblique parabolic folium *s-s* with the equation

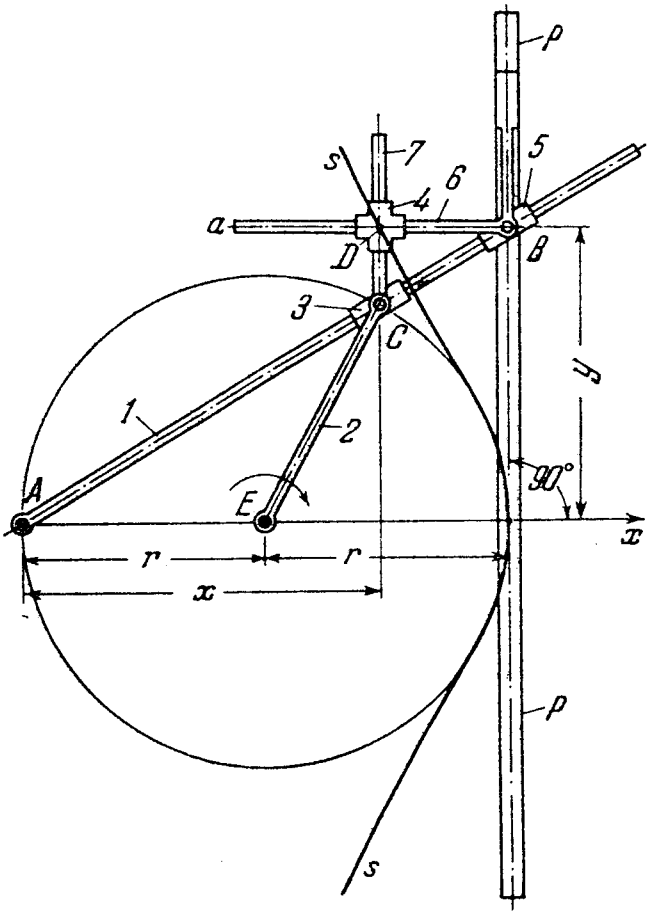
$$\rho_D = \overline{OD} = \frac{a(1 - \tan^2\varphi + b\tan\varphi)}{\cos\varphi}$$

or

$$x^3 = a(x^2 - y^2) + bxy$$

where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis *Ox*.

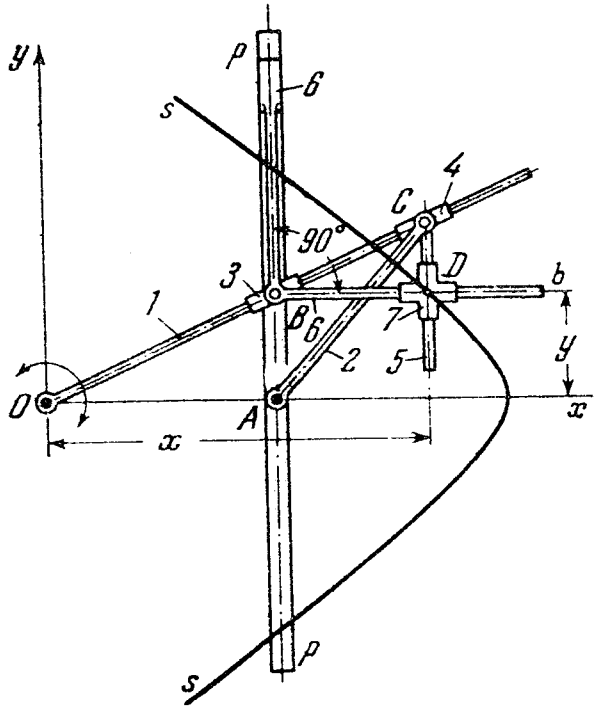
| 1184 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING VERSIERAS | LG Ge |
|---|---|---|




Link *1* turns about fixed axis *A* and is connected by sliding pairs to sliders *3* and *5*. Link *2* turns about fixed axis *E* and is connected by turning pair *C* to slider *3*. Slider *6* moves along fixed guides *p-p* and is connected by turning pair *B* to slider *5*. Cross-shaped slider *4*, with guides perpendicular to each other, is connected by sliding pairs to link *7* and to cross-piece *Ba* of link *6*. Link *7* is connected by turning pair *C* to slider *3*. When link *2* turns about axis *E*, point *D* of slider *4* describes versiera *s-s* with the equation

$$4r^2x + xy = 8r^3$$

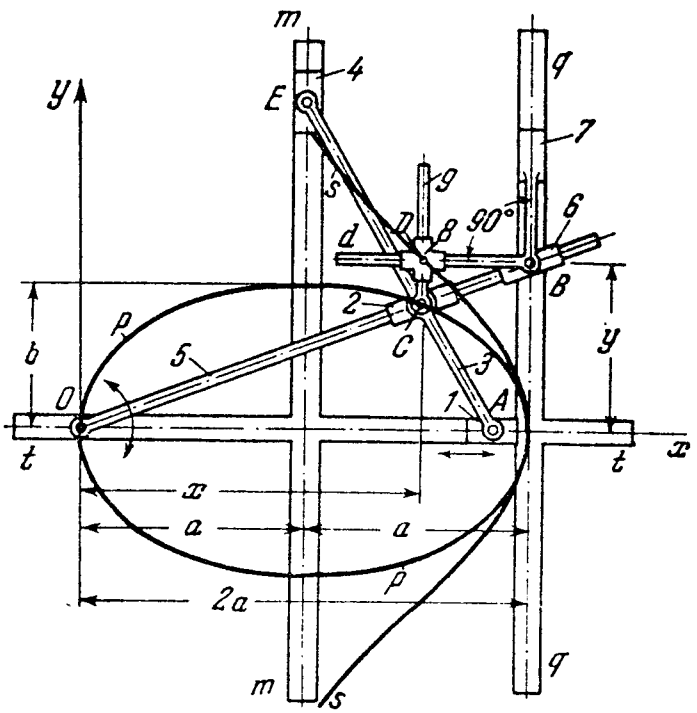
where $r = EC$.




The lengths of the links comply with the condition: $\overline{AC} = \overline{OA} = a$. Link *1* turns about fixed axis *O* and is connected by sliding pairs to sliders *3* and *4*. Slider *3* is connected by turning pair *B* to slider *6* which moves along fixed guides *p-p* whose axis passes through point *A* and is perpendicular to axis *Ox*. Cross-piece *Bb* of slider *6* is connected by a sliding pair to cross-shaped slider *7* which has guides perpendicular to each other. Link *5* is connected by turning pair *C* to slider *4* and moves in slider *7*. When link *1* turns about axis *O*, point *D* of slider *7* describes pseudoversiera *s-s* with the equation

$$xy^2 = 2a^2 (a - x).$$

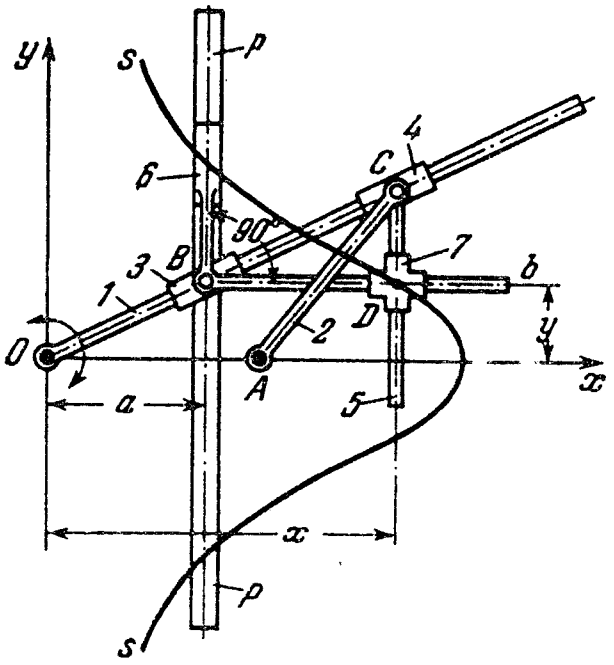
| 1186 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING VERSIERAS OF ELLIPSES | LG Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AC} = b$ and $\overline{CE} = a$, where $a$ and $b$ are the semiaxes of ellipse $p$-$p$. Slider *1* moves along fixed guides $t$-$t$ whose axis coincides with axis $Ox$. Slider *1* is connected by turning pair $A$ to link *3* which is connected by turning pairs $C$ and $E$ to sliders *2* and *4*. Slider *4* moves along fixed guides $m$-$m$ whose axis is perpendicular to axis $Ox$. Link *5*, turning about fixed axis $O$, is connected by sliding pairs to sliders *2* and *6*. Slider *7* moves along fixed guides $q$-$q$ whose axis is perpendicular to axis $Ox$. Cross-piece $Bd$ of slider *7* moves in cross-shaped slider *8* which has guides perpendicular to each other. Link *9* is connected by turning pair $C$ to slider *2* and moves in slider *8*. When slider *1* moves along guides $t$-$t$, point $C$ of slider *2* describes ellipse $p$-$p$ and point $D$ of slider *8* describes versiera $s$-$s$ of this ellipse. The equation of the versiera is

$$xy^2 = 8ab^2.$$

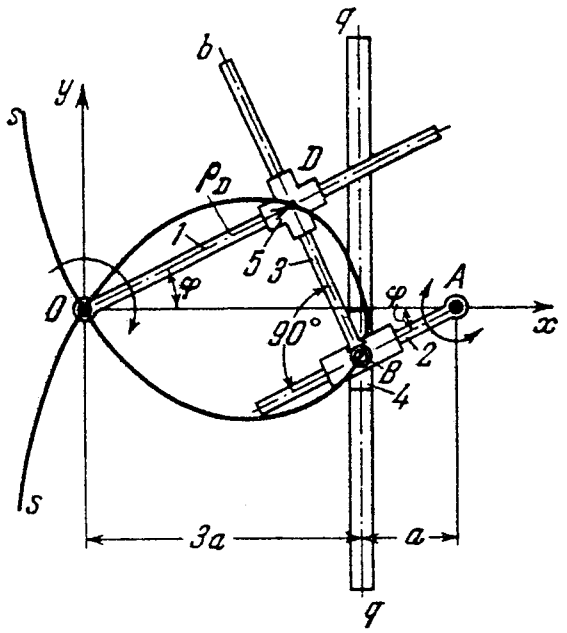
| 1187 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING VERSIERA-TYPE CURVES | LG Ge |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AC} = \overline{OA} = r$. Link *1* turns about fixed axis *O* and is connected by sliding pairs to sliders *3* and *4*. Slider *3* is connected by turning pair *B* to slider *6* which moves along fixed guides *p-p* whose axis is perpendicular to axis *Ox*. Cross-piece *Bb* of slider *6* is connected by a sliding pair to cross-shaped slider *7* which has guides perpendicular to each other. Link *5* is connected by turning pair *C* to slider *4* and moves in slider *7*. When link *1* turns about axis *O*, point *D* of slider *7* describes versiera-type curve *s-s* with the equation

$$a^2x + xy^2 = 2a^2r.$$

| 1188 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING TRISECTRICES OF MACLAURIN | LG Ge |
|---|---|---|




Link *1* turns about fixed axis *O* and is connected by a sliding pair to cross-shaped slider *5* which has guides perpendicular to each other. Link *2* turns about fixed axis *A* and is connected by a sliding pair to slider *3*. Cross-piece *Bb* of slider *3* moves in cross-shaped slider *5*. Slider *3* is connected by turning pair *B* to slider *4* which moves along fixed guides *q-q* whose axis is perpendicular to axis *Ox*. When link *1* turns about axis *O*, point *D* of slider *5* describes trisectrix of Maclaurin *s-s* with the equation

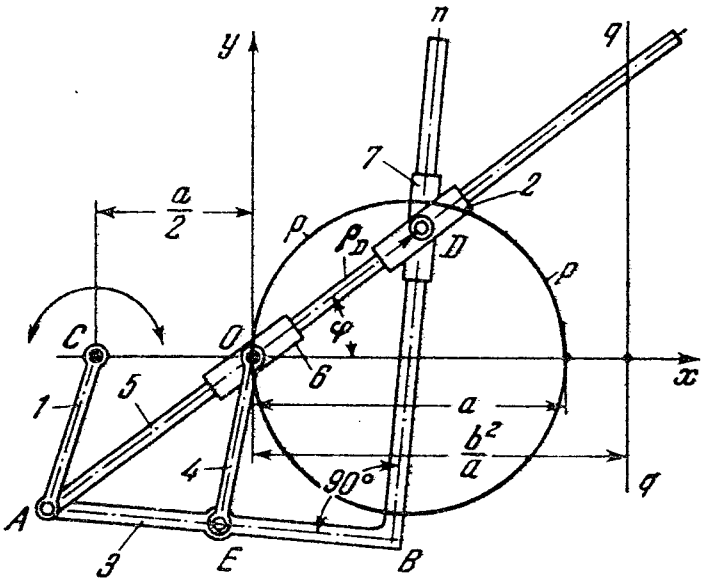
$$\rho_D = \overline{OD} = -a\,\frac{1-4\cos^2\varphi}{\cos\varphi}$$

or

$$y = x\sqrt{\frac{3a-x}{x+a}}$$

where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis *Ox*.

| 1189 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING CISSOIDS | LG Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AE} = \overline{EB} = \overline{EO} = b/2$ and $\overline{AC} = a/2$. Link *1* turns about fixed axis *C* and is connected by turning pairs *A* to links *3* and *5*. Link *5* is connected by sliding pairs to sliders *6* and *2*. Link *3* has the form of a bent lever. Arm *Bn* of link *3* is connected by a sliding pair to slider *7*. Slider *7* is connected by turning pair *D* to slider *2*. Link *4* is connected by turning pairs *E* and *O* to link *3* and to slider *6* which turns about fixed axis *O*. When link *1* turns about axis *C*, point *D* of slider *7* describes the cissoid of circle *p-p* and of straight line *q-q* which is perpendicular to axis *Ox*. The equation of the cissoid is

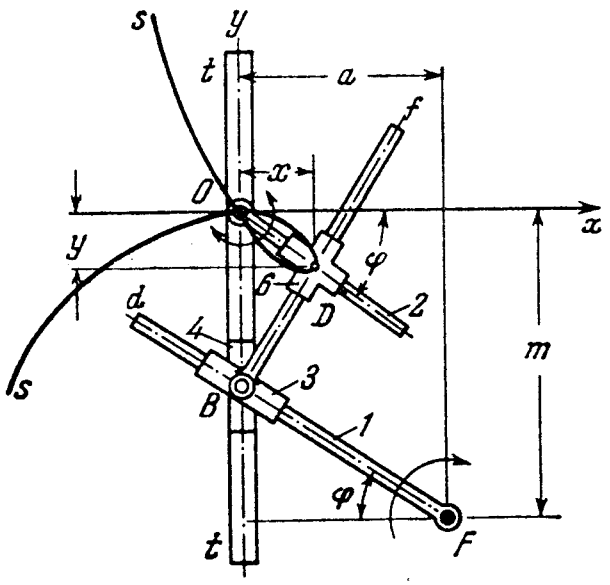
$$\rho_D = \overline{OD} = \frac{c}{\cos\varphi} - a\cos\varphi$$

or

$$y^2 = x^2\,\frac{a-(c-x)}{c-x}$$

where $\varphi$ = polar angle between vector $\rho_D$ and polar axis $Ox$
$c = b^2/a$.

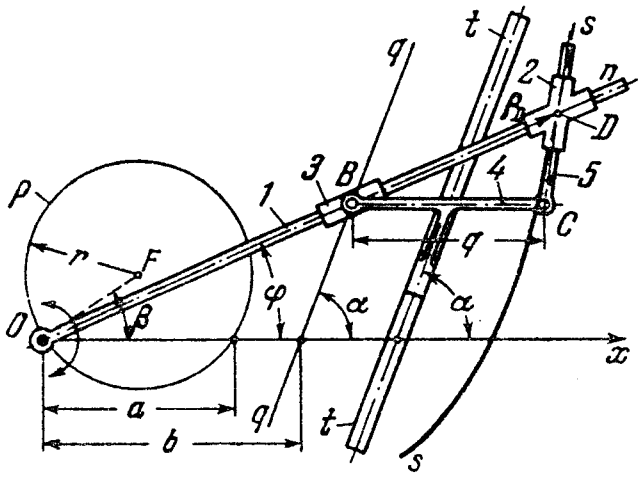
| 1190 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING OPHIURIDES | LG-Ge |
|---|---|---|




Link *1* turns about fixed axis *F* and is connected by a sliding pair to slider *3*. Slider *3* is connected by turning pair *B* to slider *4* which moves along fixed guides *t-t* whose axis is perpendicular to axis *Ox*. Link *2* turns about fixed axis *O* and is connected by a sliding pair to cross-shaped slider *6* which has guides perpendicular to each other. Slider *6* moves along cross-piece *Bf* of slider *3*. The axis of cross-piece *Bf* is perpendicular to axis *Fd* of link *1*. When link *1* turns about axis *F*, point *D* of slider *6* describes ophiuride *s-s* with the equation

$$x\,(x^2 + y^2) = y\,(mx - ay)$$

where $a$ and $m$ are constant dimensions of the mechanism.

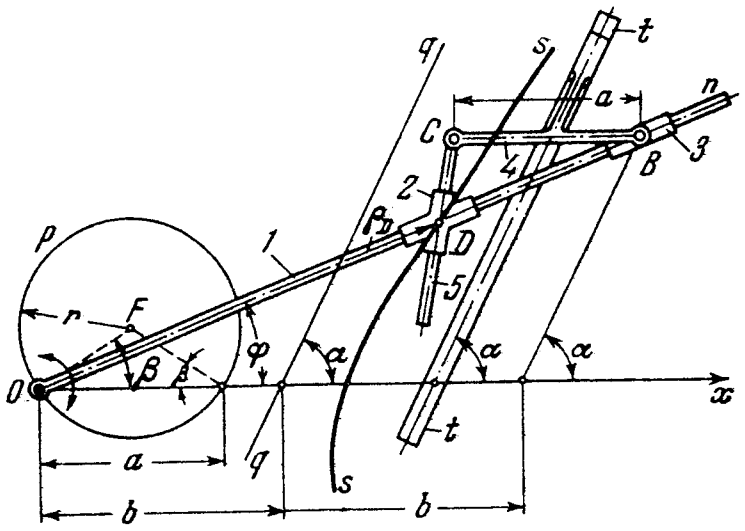



Link *1* turns about fixed axis *O* and is connected by sliding pairs to sliders *3* and *2*. Slider *4* moves along fixed guides *t-t* whose axis makes the angle $\alpha$ with axis *Ox*. Slider *4* is connected by turning pairs *B* and *C* to slider *3* and to link *5*. Link *5* moves in X-shaped slider *2* whose guides make the angle $90° - \beta$ with each other, where $\beta$ is the angle between radius $\overline{OF} = r$ of circle *p* and axis *Ox*. When link *1* turns about axis *O*, point *D* of slider *2* describes the companion *s-s* of the cissoid of circle *p*, passing through point *O*, and of straight line *q-q*. The equation of the companion *s-s* of the cissoid is

$$\rho_D = \overline{OD} = b \frac{\sin \alpha}{\sin (\alpha - \varphi)} + 2r \cos (\beta - \varphi)$$

where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis *Ox*.

| 1192 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING THE CONCOMITANT CURVES OF CISSOIDS | LG Ge |
|---|---|---|



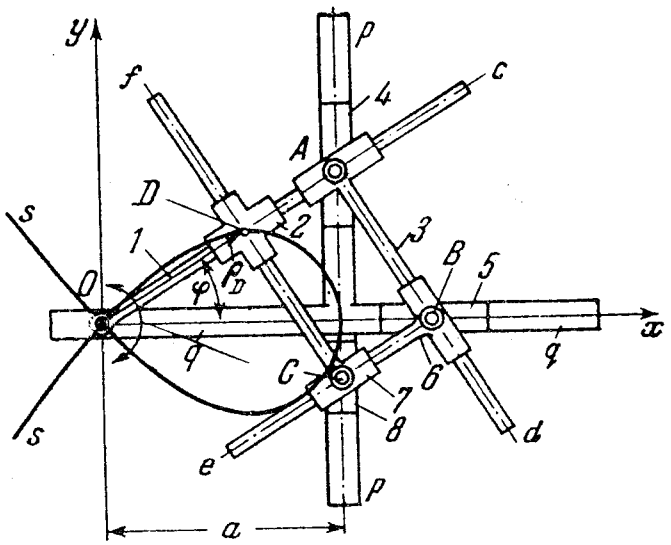

Link *1* turns about fixed axis *O* and is connected by sliding pairs to sliders *2* and *3*. Slider *4* moves along fixed guides *t-t* whose axis makes the angle $\alpha$ with axis *Ox*. Slider *4* is connected by turning pairs *B* and *C* to slider *3* and to link *5*. Link *5* moves in X-shaped slider *2* whose guides make the angle $90° - \beta$ with each other, where $\beta$ is the angle between radius $\overline{OF} = r$ of circle *p* and axis *Ox*. When link *1* turns about axis *O*, point *D* of slider *2* describes the concomitant curve *s-s* of the cissoid of circle *p*, passing through point *O*, and of straight line *q-q*. The equation of the concomitant curve *s-s* of the cissoid is

$$\rho_D = \overline{OD} = 2b \frac{\sin \alpha}{\sin (\alpha - \varphi)} - 2r \cos (\beta - \varphi)$$

where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis *Ox*.

## 1193 ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING PARABOLIC RIGHT FOLIA

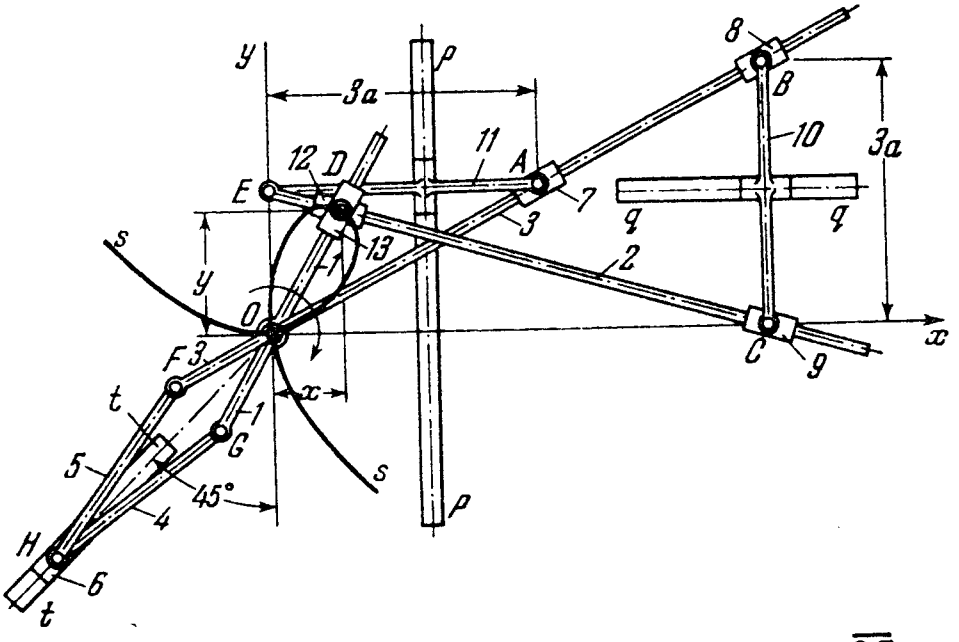





Link *1* turns about fixed axis *O* and is connected by sliding pairs to slider *3* and to cross-shaped slider *2* which has guides perpendicular to each other. Slider *3* is connected by turning pair *A* to slider *4* which moves along fixed guides *p-p* whose axis is perpendicular to axis *Ox*. Cross-piece *Ad* of slider *3* is connected by a sliding pair to slider *6* which, in turn, is connected by turning pair *B* to slider *5*. Slider *5* moves along fixed guides *q-q* whose axis coincides with axis *Ox*. Cross-piece *Be* of slider *6* is connected by a sliding pair to slider *7* which, in turn, is connected by turning pair *C* to slider *8*. Slider *8* moves along fixed guides *p-p*. Cross-piece *Cf* of slider *7* is connected by a sliding pair to slider *2*. Figure *DABC* is always a rectangle. When link *1* turns about axis *O*, point *D* of slider *2* describes parabolic folium *s-s* with the equation

$$\rho_D = \overline{OD} = a\,\frac{\cos 2\varphi}{\cos^3 \varphi} \quad \text{or} \quad x^3 = a\,(x^2 - y^2)$$

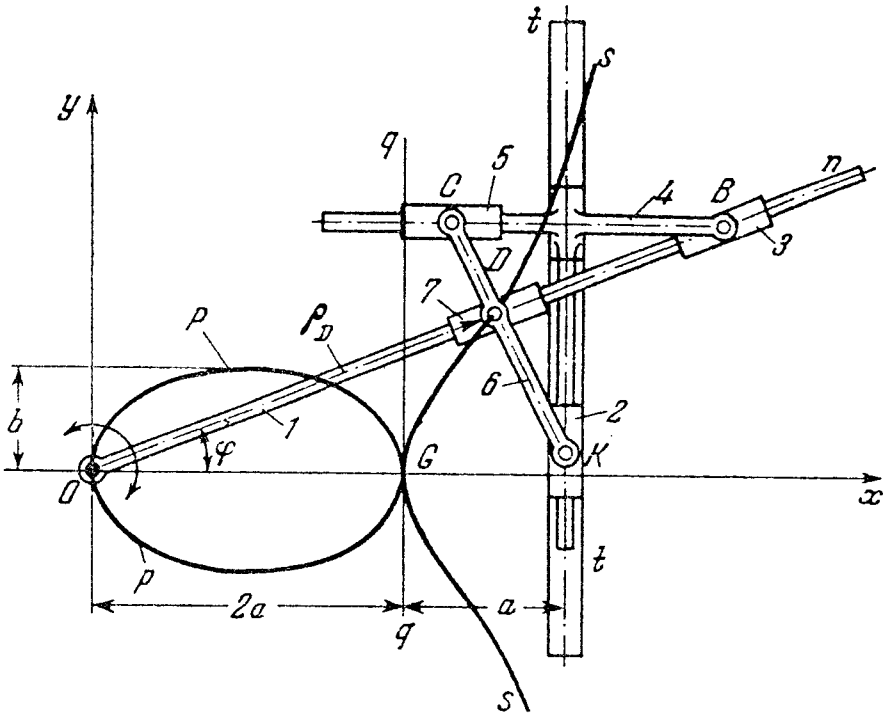
where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis *Ox*.




The lengths of the links comply with the conditions: $\overline{OF} = \overline{OG}$ and $\overline{FH} = \overline{GH}$. Links *1* and *3* turn about fixed axis *O* and are connected by turning pairs *G* and *F* to links *4* and *5*. Links *4* and *5* are connected by turning pairs *H* to slider *6* which moves along fixed guides *t-t* whose axis makes angle 45° with axis *Oy*. Link *3* is connected by sliding pairs to sliders *7* and *8*. Slider *7* is connected by turning pair *A* to slider *11* which moves in fixed guides *p-p* whose axis is perpendicular to axis *Ox*. Slider *8* is connected by turning pair *B* to slider *10* which moves along fixed guides *q-q* whose axis is perpendicular to axis *Oy*. Link *2* is connected by a sliding pair to slider *9* and by turning pair *E* to slider *11*. Sliders *12* and *13* are connected together by turning pair *D* and move along the axes of links *2* and *1*. Slider *9* is connected by turning pair *C* to slider *10*. When link *1* turns about axis *O*, point *D* of slider *12* describes Cartesian leaf *s-s* with the equation

$$x^3 + y^3 = 3axy.$$

| 1195 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING THE CONCOMITANT CURVES OF CISSOIDS OF ELLIPSES | LG Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{DK} = a$ and $\overline{DC} = b$, where $a$ and $b$ are the semiaxes of ellipse $p$-$p$. Link *1* turns about fixed axis $O$ and is connected by sliding pairs to sliders *7* and *3*. Cross-shaped slider *4* moves along fixed guides $t$-$t$ whose axis is perpendicular to axis $Ox$. Slider *4* is connected by a sliding pair to slider *5* and by turning pair $B$ to slider *3*. Link *6* is connected by turning pairs $C$, $D$ and $K$ to sliders *5*, *7* and *2*. Slider *2* is connected by a sliding pair to slider *4*. When link *1* turns about axis $O$, point $D$ of link *6* describes concomitant curve $s$-$s$ of the cissoid of ellipse $p$-$p$ and of straight line $q$-$q$ which is tangent to the ellipse at point $G$. The equation of concomitant curve $s$-$s$ is

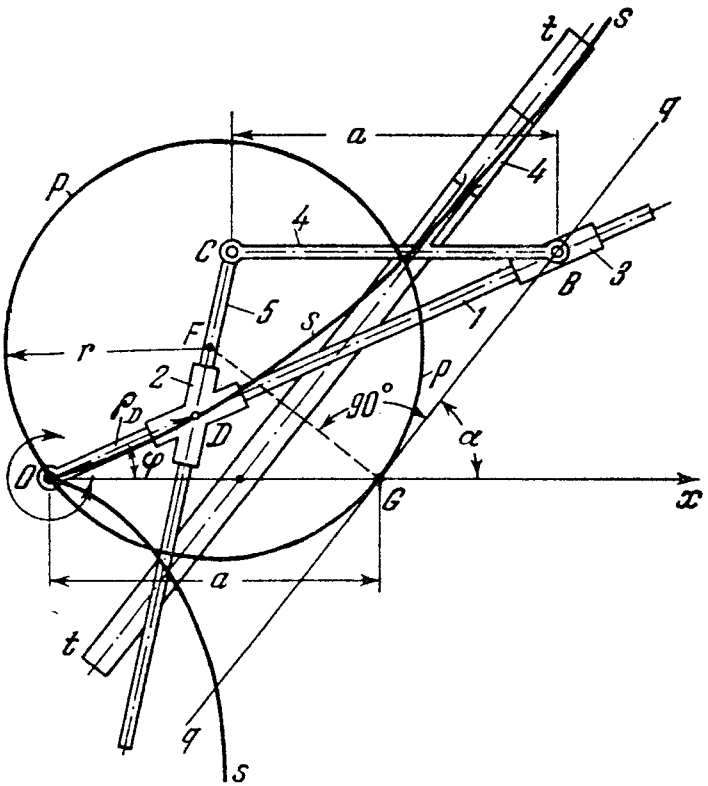
$$\rho_D = \overline{OD} = \frac{4a}{\cos\varphi} - \frac{2\frac{b^2}{a}\cos\varphi}{\sin^2\varphi + \frac{b^2}{a^2}\cos^2\varphi}$$

or

$$y^2 = \frac{b^2}{a^2}\,\frac{x^2 - 2a}{4a - x}$$

where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis $Ox$.

| 1196 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING CISSOIDS OF DE LONGCHAMPS | LG Ge |
|---|---|---|

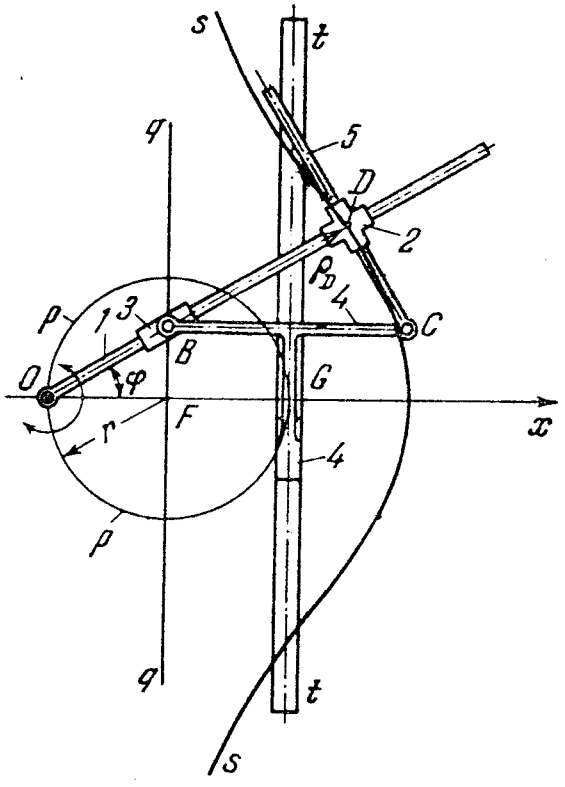



Link *1*, turning about fixed axis *O*, is connected by sliding pairs to sliders *2* and *3*. Slider *4* moves along fixed guides *t-t* whose axis makes the angle $\alpha$ with axis *Ox*. Slider *4* is connected by turning pair *C* to link *5* and by turning pair *B* to slider *3*. Link *5* moves in X-shaped slider *2* whose guides make the angle $\alpha$ with each other. When link *1* turns about axis *O*, point *D* of slider *2* describes cissoid of De Longchamps *s-s* with the equation

$$\rho_D = \overline{OD} = 2r\,\frac{\sin^2\varphi}{\sin(\alpha-\varphi)}$$

where $\varphi$ is the polar angle between vector $\boldsymbol{\rho}_D$ and polar axis *Ox*. The cissoid of De Longchamps is the cissoid of circle *p-p*, of radius *r* and passing through point *O*, and of straight line *q-q*, tangent to circle *p-p* at point *G*.

| 1197 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING DE LONGCHAMPS CURVES | LG Ge |
|---|---|---|

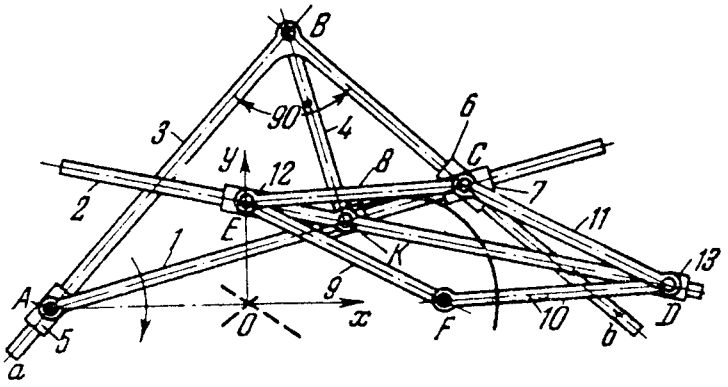



Link *1* turns about fixed axis *O* and is connected by sliding pairs to sliders *3* and *2*. Slider *4* moves along fixed guides *t-t* whose axis is perpendicular to axis *Ox*. Slider *4* is connected by turning pairs *B* and *C* to slider *3* and to link *5*. Link *5* moves in cross-shaped slider *2* which has guides perpendicular to each other. When link *1* turns about axis *O*, point *D* of slider *2* describes De Longchamps curve *s-s* with the equation

$$\rho_D = \overline{OD} = \frac{r}{\cos\varphi} + 2r\cos\varphi$$

where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis *Ox*. The De Longchamps curve is the companion of a cissoid of the circle *p-p* (of radius *r*, with its centre at *F* and passing through point *O*) and of straight line *q-q*, passing through centre *F*.

| 1198 | VYATKIN LINK-GEAR MECHANISM FOR TRACING CASSINIAN OVALS | LG Ge |
|---|---|---|



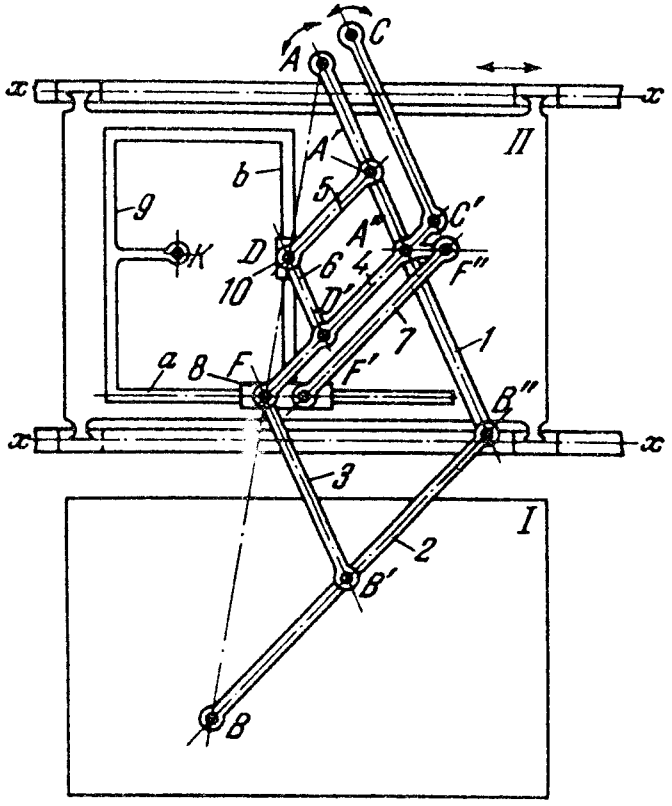

The lengths of the links comply with the conditions: $\overline{EC} = \overline{CD} = \overline{DF} = \overline{FE}$, i.e. figure *ECDF* is a rhombus linkage. Arm *Ba* of bent link *3* moves in slider *5* which turns about fixed axis *A*. Arm *Bb* of link *3* moves in slider *6* which is connected by turning pair *C* to slider *7*. Link *4* is connected by turning pair *B* to link *3* and by a sliding pair to link *1*. The axis of link *4* is perpendicular to that of link *1*. Links *8*, *9*, *10* and *11* are connected together by turning pairs *E*, *F*, *D* and *C*. Links *9* and *10* turn about fixed axis *F*. Link *2* is connected by turning pair *K* to link *4* and by sliding pairs to sliders *12* and *13*, constituting diagonal *ED* of parallelogram *ECDF*. When link *1* turns about axis *A*, point *K* of link *4* describes a Cassinian oval with the equation (with respect to the origin of coordinates *O*)

$$(x^2 + y^2) - 2d^2 (x^2 - y^2) = a^4 - d^4$$

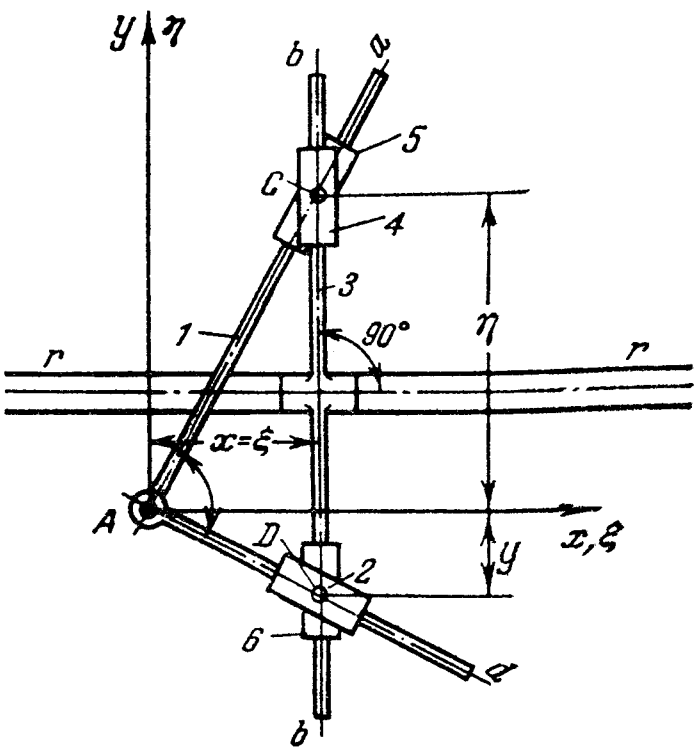
where $a = \overline{BK}$

$2d = \overline{AF} = 2\overline{OF} = 2\overline{OA}$.

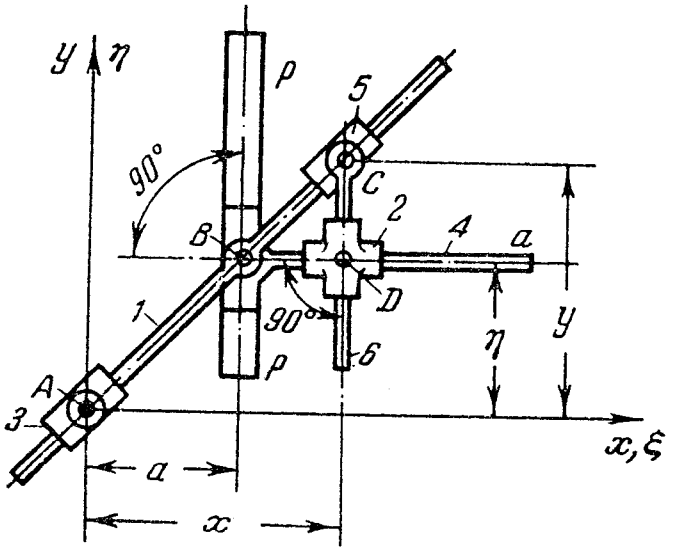
| 1199 | LINK-GEAR MECHANISM FOR DRAWING ISOMETRIC PROJECTIONS | LG Ge |
|---|---|---|




The mechanism consists of two pantographs. The first pantograph consists of links *1*, *2*, *3* and *4*. The second, of links *1*, *4*, *5* and *6*. Link *1* turns about fixed axis *A*. Link *4* turns about fixed axis *C*. Link *4* is connected by turning pair *F* to link *3*. Links *4* and *7* are connected by turning pairs *F* and *F'* to slider *8* which moves along side *a* of frame *9*. Links *5* and *6* are connected by turning pair *D* to slider *10* which moves along side *b* of frame *9*. When stylus *B* follows the outline of a plane figure, pencil *K* draws a distorted projection of the figure. The total distortion of the scale of the figure equals 1/2. Besides, the additional distortion of the scale along the *x* axis equals $\overline{AD}/\overline{AF}$, so that the total distortion along the *x* axis equals $\tau/2$. To obtain such projection, the lengths of the links should comply with the conditions: $\overline{AA'} = \overline{A'D} = \overline{A''D}$; $\overline{DD'} = \overline{D'F} = \overline{A'A''}$, $\overline{AB''} = 2\overline{CC'} = \overline{B''B} = 2\overline{B'B''} = 2\overline{B'B} = 2\overline{A''F} = 2\overline{F'F''}$, $\overline{FF'} = \overline{A''F''}$ and $\overline{A''C'} = \overline{AC}$. Under these conditions, points *A*, *D*, *F* and *B* lie on a straight line, and the distances $\overline{AF}$ and $\overline{FB}$ are equal. If the position of point *D* is taken so that $\tau = 0.577$, i.e. $\overline{AD} = 0.577\overline{AF}$, then the projection drawn by the mechanism is isometric.



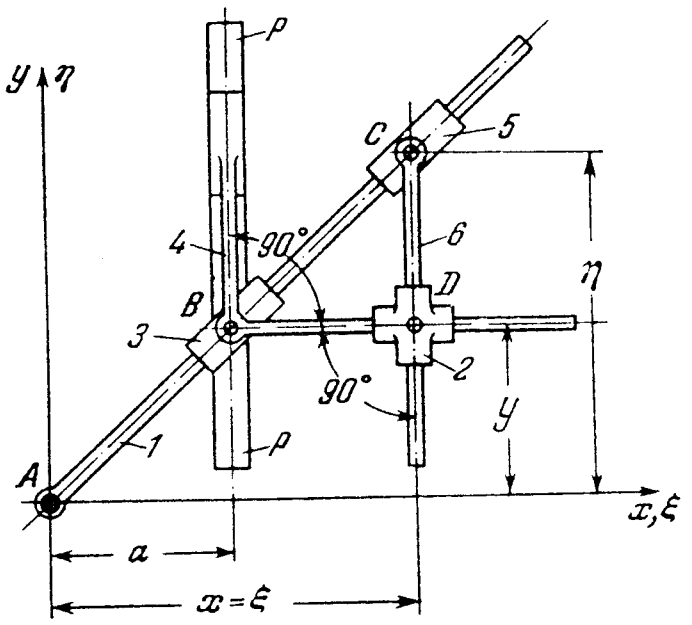

Bent link *1* turns about fixed axis *A*. Slider *3* moves along fixed guides *r-r*. Sliders *4* and *5* are connected together by turning pair *C*. Sliders *5* and *2* move along arms *Aa* and *Ad* of link *1*. Sliders *2* and *6* are connected together by turning pair *D*. Sliders *4* and *6* move along cross-piece *b-b* of slider *3*. When point *C* follows a given curve $\varphi(\xi, \eta) = 0$ with the coordinates $\xi$ and $\eta$, point *D* traces curve $F(x, y) = 0$ with the coordinates $x$ and $y$. Coordinates $\xi$, $\eta$, $x$ and $y$ are related by the conditions $x = \xi$ and $y = \xi^2/\eta$. Thus the mechanism converts curve $\varphi(\xi, \eta) = 0$ into curve $F(x, y) = 0$.




Slider *3* turns about fixed axis *A*. Link *1* is connected by sliding pairs to sliders *3* and *5* and by turning pair *B* to slider *4* which moves along fixed guides *p-p*. Link *6* is connected by turning pair *C* to slider *5* and by a sliding pair to cross-shaped slider *2* which has guides perpendicular to each other. Slider *2* is connected by a sliding pair to extension *Ba* of slider *4*. When point *D* of slider *2* follows a given curve $\varphi(\xi, \eta) = 0$ with the coordinates $\xi$ and $\eta$, point *C* of slider *5* traces curve $F(x, y) = 0$ with the coordinates $x$ and $y$. Coordinates $\xi$, $\eta$, $x$ and $y$ are related by the conditions

$$x = \xi \quad \text{and} \quad y = \frac{1}{a}\xi\eta$$

where $a$ is a constant dimension of the mechanism. Thus the mechanism converts curve $\varphi(\xi, \eta) = 0$ into curve $F(x, y) = 0$.

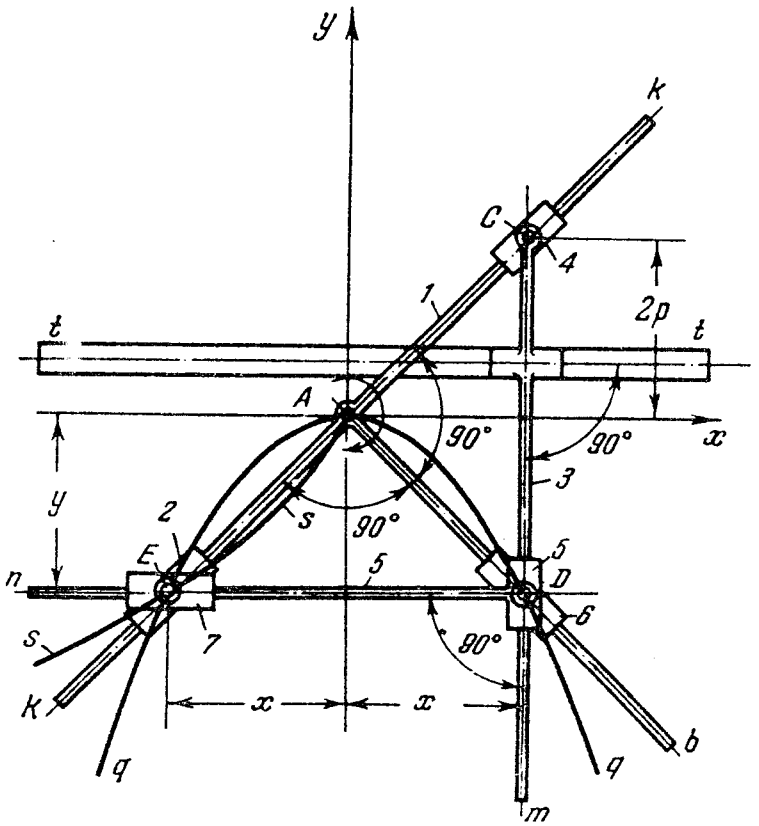



Link *1*, turning about fixed axis *A*, is connected by sliding pairs to sliders *3* and *5*. Link *4* is connected by turning pair *B* to slider *3* and moves along fixed guides *p-p*. Cross-shaped slider *2*, with guides perpendicular to each other, is connected by sliding pairs to link *4* and link *6*. Link *6* is connected by turning pair *C* to link *5*. When point *C* of slider *5* follows a given curve $\varphi(\xi, \eta) = 0$ with the coordinates $\xi$ and $\eta$, point *D* of slider *2* traces curve $F(x, y) = 0$ with the coordinates $x$ and $y$. Coordinates $\xi$, $\eta$, $x$ and $y$ are related by the conditions

$$x = \xi \quad \text{and} \quad y = a\frac{\eta}{\xi}$$

where $a$ is a constant dimension of the mechanism. Thus the mechanism converts curve $\varphi(\xi, \eta) = 0$ into curve $F(x, y) = 0$.

| 1203 | LINK-GEAR MECHANISM FOR TRACING CUBIC PARABOLAS | LG Ge |
|---|---|---|

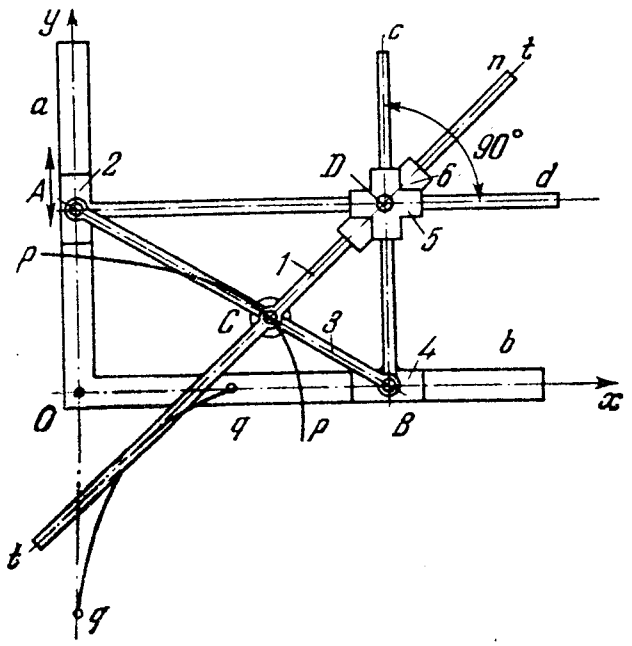



T-shaped link *1* turns about fixed axis *A*. Cross-piece *k-k* of link *1* is connected by sliding pairs to sliders *2* and *4*. Cross-piece *Ab* of link *1* is connected by a sliding pair to slider *6*. Slider *3* moves along fixed guides *t-t* whose axis is parallel to axis *Ax*. Cross-piece *Cm* of slider *3* is connected by turning pair *C* to slider *4* and by a sliding pair to slider *5*. Sliders *5* and *6* are connected together by turning pair *D*. Cross-piece *Dn* of slider *5* is connected by a sliding pair to slider *7* which, in turn, is connected by turning pair *E* to slider *2*. When link *1* turns about axis *A*, point *D* of slider *6* describes parabola *q-q* and point *E* of slider *2* describes cubic parabola *s-s* with the equation

$$x^2 = -\frac{1}{2p} y^3$$

where $2p$ is a constant dimension of the mechanism.

| 1204 | LINK-GEAR MECHANISM FOR TRACING EVOLUTES OF ELLIPSES | LG Ge |
|---|---|---|




Link *3* is connected by turning pairs *A* and *B* to sliders *2* and *4* which move along fixed guides *a* and *b*. Cross-pieces *Ad* and *Bc* of sliders *2* and *4* move in cross-shaped slider *5*. Link *1* is connected by turning pair *C* to link *3* and by a sliding pair to slider *6*. Sliders *5* and *6* are connected together by turning pair *D*. When slider *2* moves along guides *a*, point *C* of link *3* describes ellipse *p-p* with the equation

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

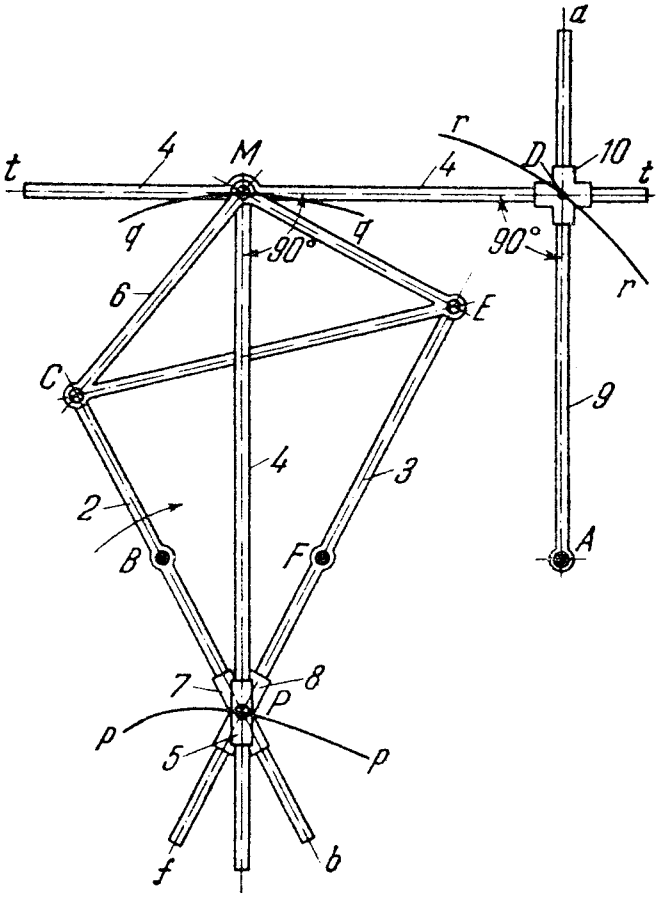
where $a = \overline{AC}$

$b = \overline{CB}$.

At the same time, straight line *t-t* envelops the evolute *q-q* of the ellipse. The equation of the evolute is

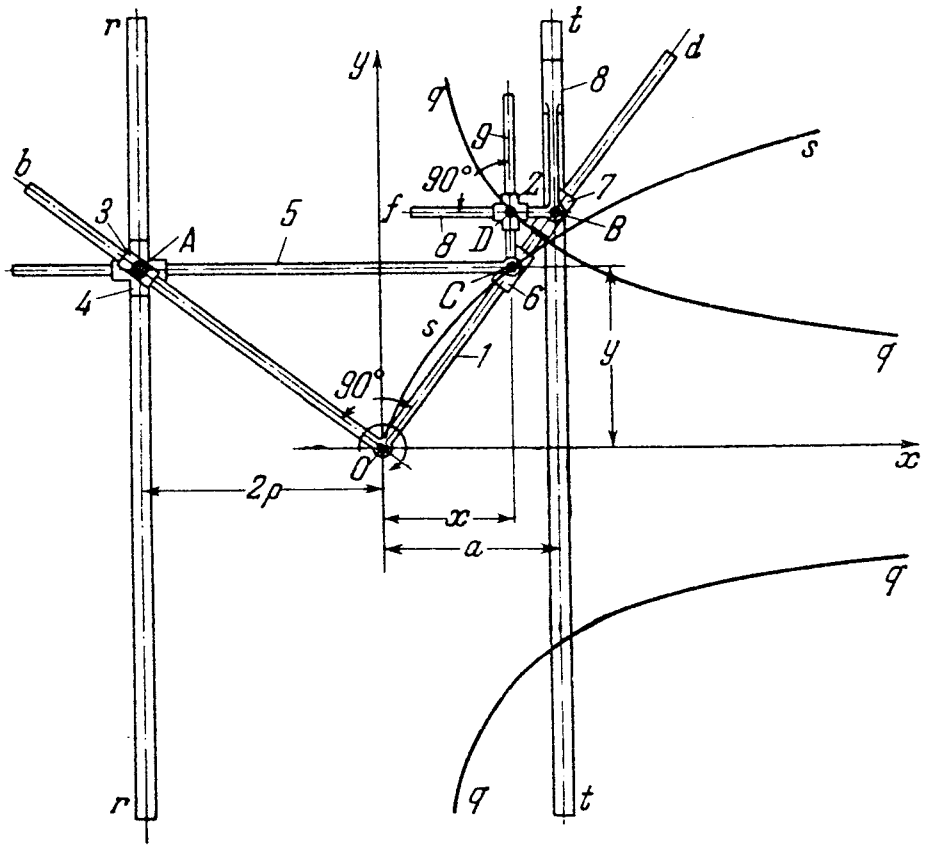
$$(ax)^{2/3} + (by)^{2/3} = (a^2 - b^2)^{2/3}.$$

| 1205 | LINK-GEAR MECHANISM FOR DRAWING TANGENTS TO CONNECTING-ROD CURVES | LG Ge |
|---|---|---|




The mechanism is based on four-bar linkage *BCEF* in which point *M* of connecting rod *6* describes curve *q-q*. Sliders *7* and *8* are connected together by turning pair *P* and move along axes *Bb* and *Ff* of links *2* and *3*. Link *4* is connected by turning pair *M* to link *6* and by a sliding pair to slider *5*. Slider *5* is connected by turning pair *P* to sliders *7* and *8*. Point *P* describes curve *p-p* which is the space centrode of link *6*. Straight line *tMt*, belonging to link *4*, is always tangent to connecting-rod curve *q-q*. Link *9*, turning about fixed axis *A*, is connected by a sliding pair to cross-shaped slider *10* which has guides perpendicular to each other. Point *D* of slider *10* describes curve *r-r* which is the pedal curve of connecting rod curve *q-q*, with respect to centre *A*.

| 1206 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING POLYTROPIC CURVES | LG Ge |
|---|---|---|




Link *1* has the form of a bent lever. Arm *Ob* of link *1* is connected by a sliding pair to slider *3* and arm *Od* by sliding pairs to sliders *6* and *7*. Slider *3* is connected by turning pair *A* to cross-shaped slider *4* which has guides perpendicular to each other. Slider *4* moves along fixed guides *r-r* whose axis is parallel to axis *Oy*. Link *5* is connected by turning pair *C* to slider *6* and by a sliding pair to slider *4*. Slider *8* moves along fixed guides *t-t* whose axis is parallel to axis *Oy*. Slider *8* is connected by turning pair *B* to slider *7*. Cross-piece *Bf* of slider *8* has its axis parallel to axis *Ox* and is connected by a sliding pair to cross-shaped slider *2* which has guides perpendicular to each other. Link *9* is connected by turning pair *C* to slider *6* and by a sliding pair to slider *2*. When link *1* turns about fixed axis *O*, point *C* of slider *6* describes parabola *s-s* and point *D* of slider *2* describes the upper branch of polytropic curve *q-q* with equation

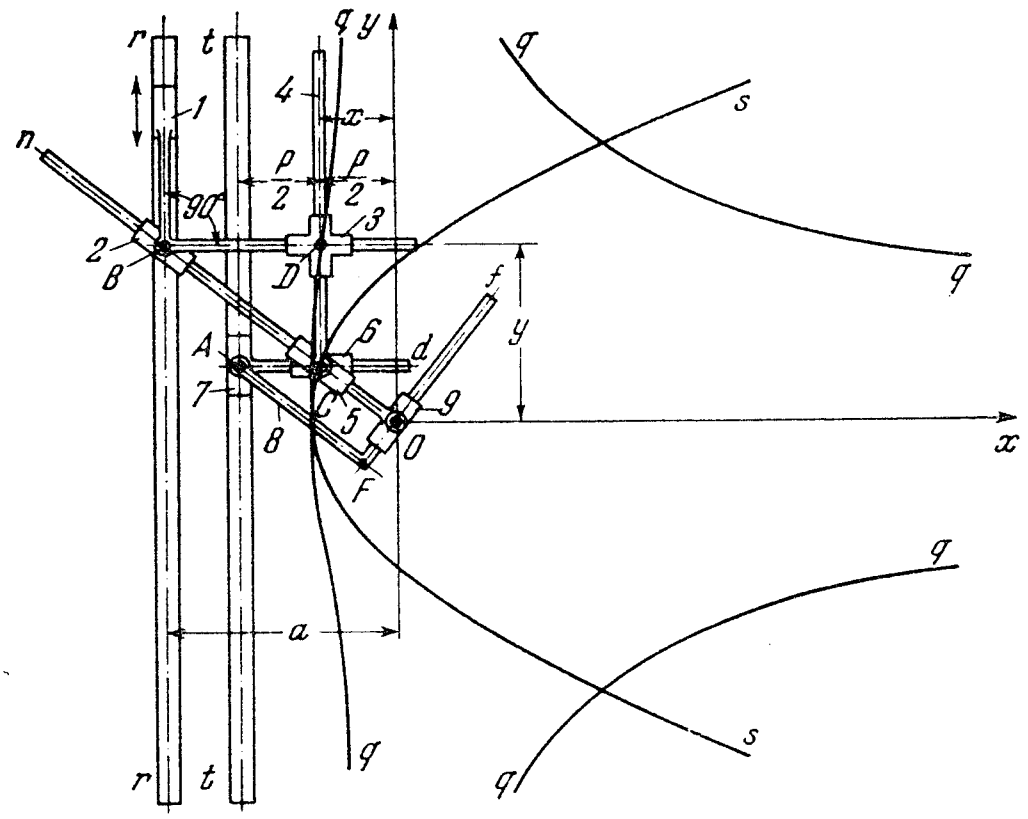
$$y \quad (-1/2$$

where $k = a\sqrt{2p}$

$2p$ and $a$ = constant dimensions of the mechanism.

To trace the lower branch of curve *q-q*, the links of the mechanism are reassembled symmetric to the axis *Ox*.

| 1207 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING FOURTH-ORDER HYPERBOLAS | LG Ge |
|---|---|---|

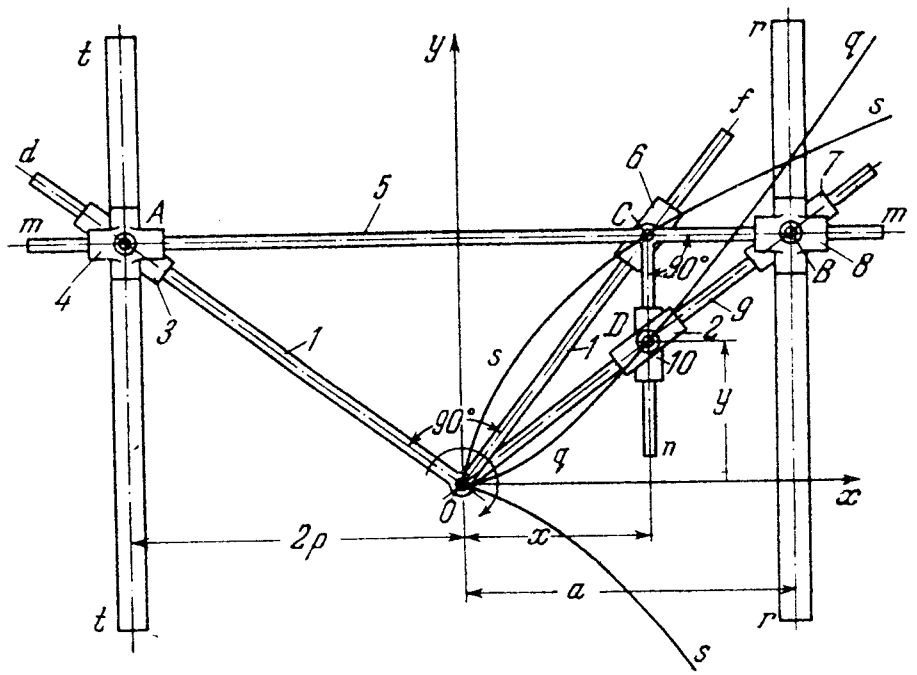



Slider *1* moves along fixed guide *r-r* whose axis is parallel to axis *Oy*. Slider *1* is connected by turning pair *B* to slider *2* and by a sliding pair to cross-shaped slider *3* which has guides perpendicular to each other. Slider *7* moves along fixed guides *t-t* whose axis is parallel to axis *Oy*. Slider *7* is connected by turning pair *A* to bent link *8* having angle *AFf* equal to 90°. Cross-piece *Ad* of slider *7* has its axis parallel to axis *Ox* and is connected by a sliding pair to slider *6*. Sliders *6* and *5* are connected together by turning pair *C*. Arm *Ff* of link *8* is connected by a sliding pair to slider *9* which turns about fixed axis *O*. Cross-piece *On* of slider *9* is connected by sliding pairs to sliders *5* and *2*. Link *4* is connected by turning pair *C* to sliders *5* and *6*, and by a sliding pair to slider *3*. When slider *1* moves along guides *r-r*, point *C* of slider *6* describes parabola *s-s*, and point *D* of slider *3* describes a fourth-order hyperbola having three branches. The equation of hyperbola *q-q* is

$$x^2y^2 - 2pa^2x = a^2p^2$$

where *a* and *p* are constant dimensions of the mechanism.

| 1208 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING HIGH-ORDER PARABOLAS | LG Ge |
|---|---|---|



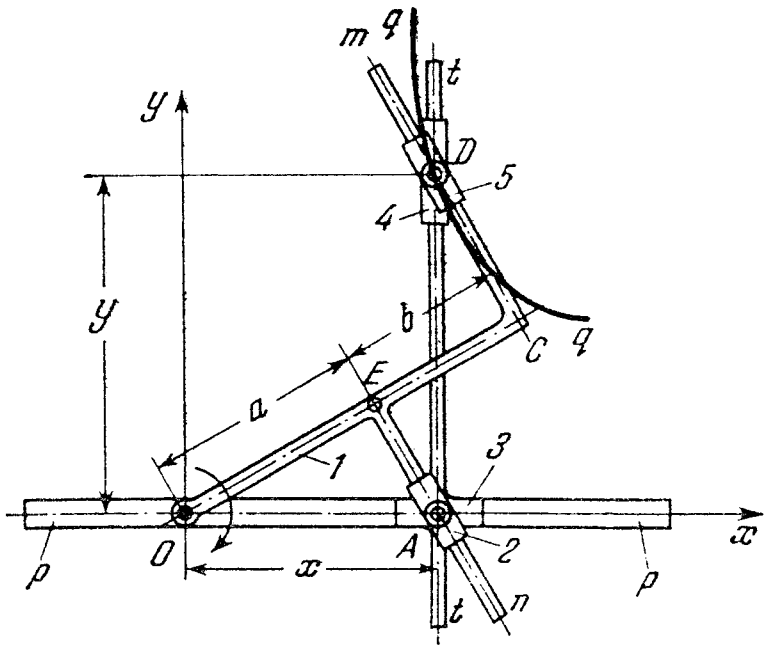

Link *1* has the form of a bent lever and turns about fixed axis *O*. Arms *Od* and *Of* of link *1* are connected by sliding pairs to sliders *3* and *6*. Slider *3* is connected by turning pair *A* to cross-shaped slider *4* which has guides perpendicular to each other. Slider *4* moves along fixed guides *t-t* whose axis is parallel to axis *Oy*. Slider *7* is connected by turning pair *B* to cross-shaped slider *8* which has guides perpendicular to each other. Slider *8* moves along fixed guides *r-r* whose axis is parallel to axis *Oy*. Cross-piece *m-m* of T-shaped link *5* is connected by sliding pairs to sliders *4* and *8*. Cross-piece *Cn* of link *5* is connected by a sliding pair to slider *10*. Slider *6* is connected by turning pair *C* to link *5*. Slider *10* is connected by turning pair *D* to slider *2*. When link *1* turns about axis *O*, point *C* of slider *6* describes parabola *s-s*, and point *D* of slider *10* describes high-order parabola *q-q* with the equation

$$y = kx^{3/2}$$

where $k = \frac{\sqrt{2p}}{a}$

and $a$ = constant dimensions of the mechanism.

1209 **ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING INCLINED-NODE CURVES** LG Ge

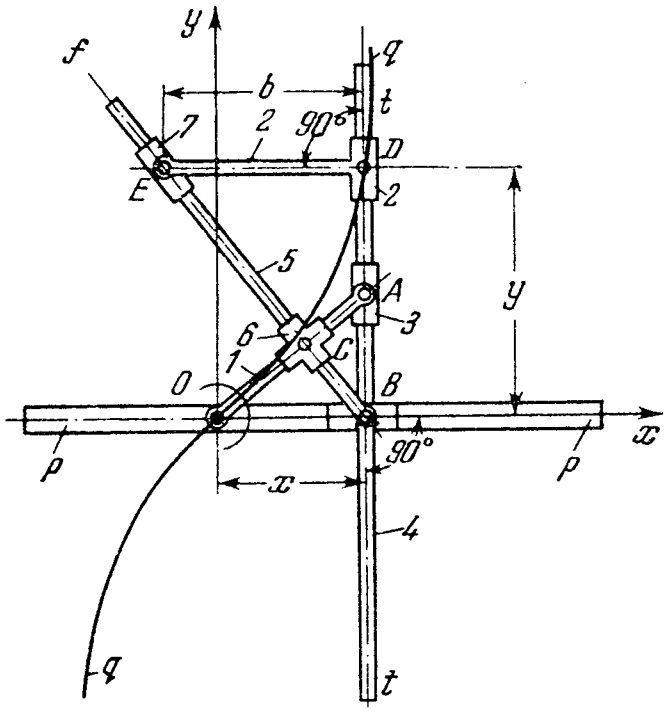



Link *1* has the form of a double bent lever with right angles at points *C* and *E*, i.e. angles *OEn* and *OCm* equal 90°. Link *1* turns about fixed axis *O*. Arm *Cm* of link *1* is connected by a sliding pair to slider *5*; cross-piece *En* is connected by a sliding pair to slider *2*. Slider *2* is connected by turning pair *A* to slider *3* which moves along fixed guides *p-p* whose axis coincides with axis *Ox*. Cross-piece *t-t* of link *3* is parallel to axis *Oy* and is connected by a sliding pair to slider *4*. Sliders *4* and *5* are connected together by turning pair *D*. When link *1* turns about axis *O*, point *D* of slider *4* describes an inclined-node curve with the equation

$$\frac{a^2}{x^2}+\frac{b^2}{y^2}=1$$

where $a=\overline{OE}$ and $b=\overline{EC}$ are constant dimensions of the mechanism.

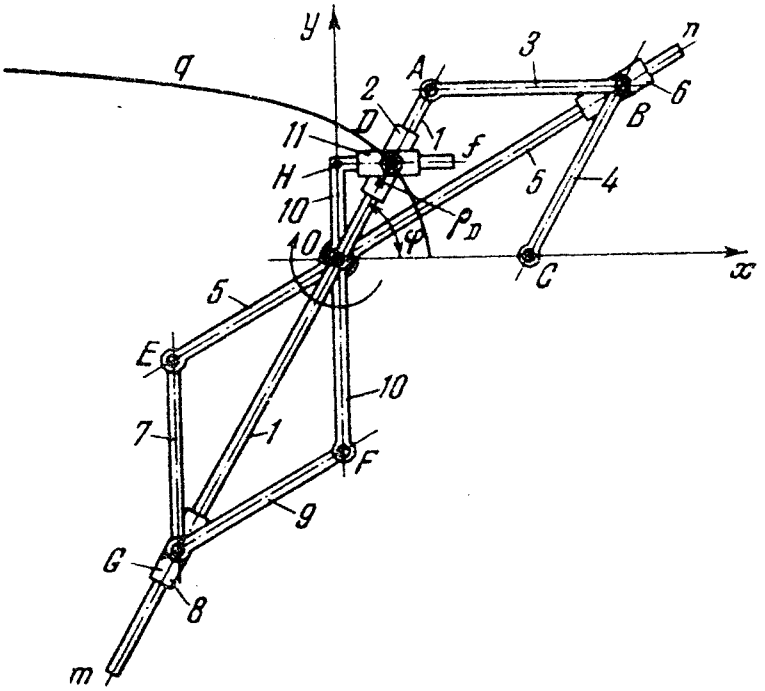
| 1210 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING INCLINED-NODE CURVES | LG Ge |
|---|---|---|




Link *1*, turning about fixed axis *O*, is connected by turning pair *A* to slider *3* and by a sliding pair to cross-shaped slider *6* which has guides perpendicular to each other. Slider *4* moves along fixed guides *p-p* whose axis coincides with axis *Ox*. Cross-piece *t-t* of slider *4* is connected by sliding pairs to sliders *2* and *3*. Slider *7* is connected by turning pair *E* to slider *2* and moves along axis *Bf* of link *5* which is connected by turning pair *B* to slider *4*. When link *1* turns about axis *O*, point *D* of slider *2* describes inclined-node curve *q-q* with the equation

$$\frac{a^2}{x^2} - \frac{b^2}{y^2} = 1$$

where $a = \overline{OA}$ and $b = \overline{DE}$ are constant dimensions of the mechanism.

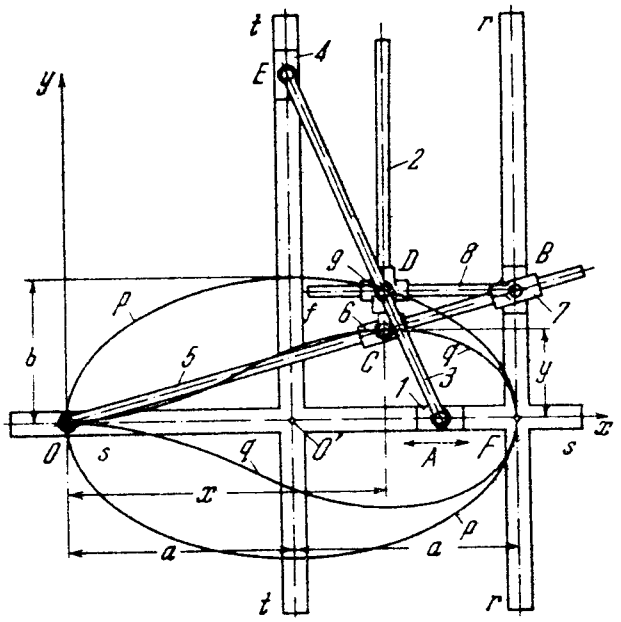



The lengths of the links comply with the conditions: $\overline{OA} = \overline{AB} = \overline{BC} = \overline{CO} = \overline{OF} = \overline{FG} = \overline{GE} = \overline{EO} = a$ and $\overline{OH} = a/2$. Figures *OABC* and *OFGE* are rhombus linkages. Link *1*, turning about fixed axis *O*, is connected by sliding pairs to sliders *2* and *8*, and by turning pair *A* to link *3*. Link *5*, turning about axis *O*, is connected by a sliding pair to slider *6* and by turning pair *E* to link *7*. Link *10* has the form of a bent lever with angle *FHf* equal to 90°. Link *10* turns about axis *O* and is connected by turning pair *F* to link *9*. Arm *Hf* of link *10* moves in slider *11* which is connected by turning pair *D* to slider *2*. Links *7* and *9* are connected by turning pairs *G* to slider *8* which moves along axis *Om* of link *1*. Link *3* is connected by turning pair *B* to slider *6* which moves along axis *On* of link *5*. Slider *6* is connected by turning pair *B* to link *4* which turns about fixed axis *C*. When link *1* turns about axis *O*, point *D* of slider *2* describes a trisecant curve with the equation

$$\rho_D = \overline{OD} = \frac{a}{2\cos\frac{\varphi}{2}} \quad \text{or} \quad (a^2 - y^2)(x^2 + y^2) = \frac{a^4}{4}$$

where $a$ = constant dimension of the mechanism
$\varphi$ = polar angle between vector $\rho_D$ and polar axis *Ox*.

| 1212 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR CONVERTING ELLIPSES INTO ANTIVERSIERAS | LG Ge |
|---|---|---|



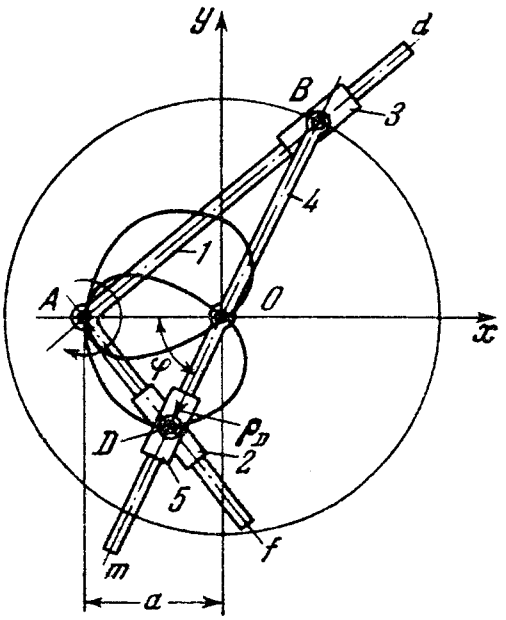

The lengths of the links comply with the conditions: $\overline{AD} = b$, $\overline{DE} = a$ and $\overline{OO'} = \overline{O'F} = a$, where $a$ and $b$ are semiaxes of ellipse $p$-$p$ that is to be converted. The axis of guides $t$-$t$ passes through centre $O'$ of ellipse $p$-$p$, and the axis of guides $r$-$r$ is tangent to the ellipse at point $F$. Slider *1* moves along fixed guides $s$-$s$ whose axis coincides with axis $Ox$. Slider *1* is connected by turning pair $A$ to link *3*. Link *3* is connected by turning pair $D$ to cross-shaped slider *9* which has guides perpendicular to each other. Link *3* is connected by turning pair $E$ to slider *4* which moves along fixed guides $t$-$t$ whose axis is parallel to axis $Oy$. Link *5*, turning about fixed axis $O$, is connected by sliding pairs to sliders *6* and *7*. Slider *7* is connected by turning pair $B$ to slider *8* which moves along fixed guides $r$-$r$ whose axis is parallel to axis $Oy$. Cross-piece $Bf$ of slider *8* is connected by a sliding pair to slider *9*. Link *2* is connected by turning pair $C$ to slider *6* and by a sliding pair to slider *9*. When slider *1* moves along guides $s$-$s$, point $D$ of slider *9* describes ellipse $p$-$p$ and point $C$ of slider *6* describes antiversiera $q$-$q$ of the ellipse. The equation of the antiversiera is

$$x^4 - 2ax^3 + 4\frac{a^4}{b^2}y^2 = 0.$$

If the turning axis of link *5* is moved to point $O'$, then point $C$ describes a curve with the equation

$$x^4 - a^2x^2 + \frac{a^4}{b^2}y^2 = 0.$$

| 1213 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING CURVES OF GERABEC | LG Ge |
|---|---|---|



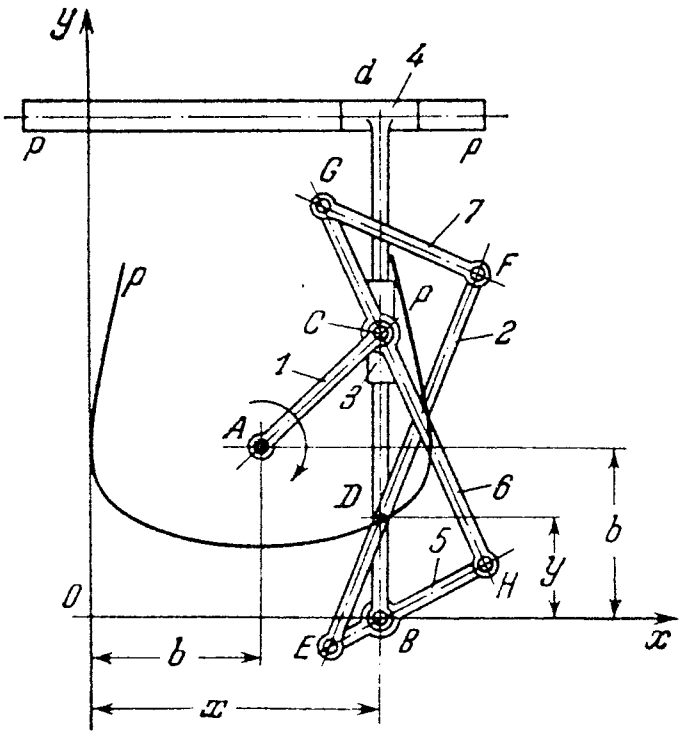

Link *1* has the form of a bent lever with the angle $fAd$ equal to 90°. Link *1* turns about fixed axis *A*. Arm *Ad* of link *1* moves in slider *3* which, in turn, is connected by turning pair *B* to link *4*. Link *4* turns about fixed axis *O*. Sliders *2* and *5* are connected together by turning pair *D*, and move along axis *Af* of link *1* and axis *Bm* of link *4*. When link *1* turns about axis *A*, point *D* of slider *2* describes a curve of Gerabec with the equation

$$\rho_D = \overline{OD} = a\frac{a + b\cos\varphi}{b + a\cos\varphi}$$

or

$$a^2(x - a)^2(x^2 + y^2) = b^2(ax - x^2 - y^2)^2$$

where $a$ and $b = \overline{OB}$ are constant dimensions of the mechanism
$\varphi$ = polar angle between vector $\rho_D$ and polar axis $Ox$.

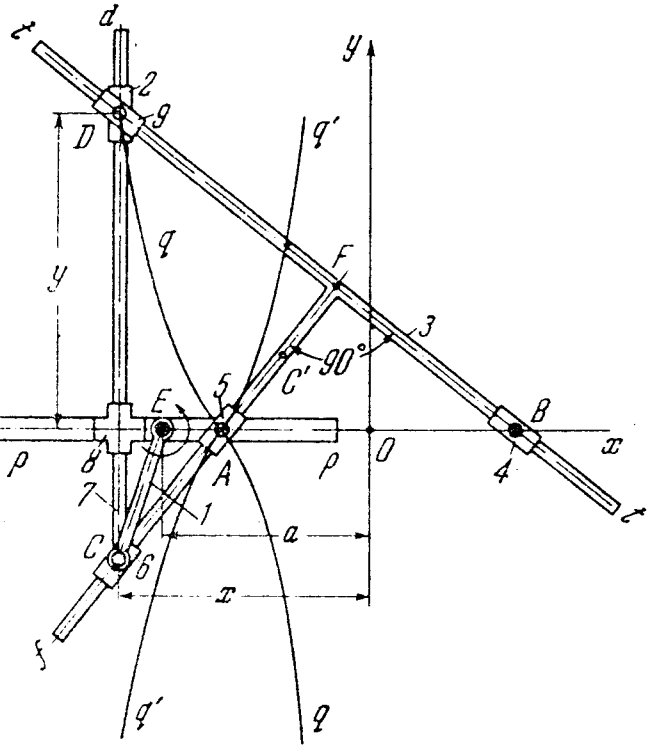



The lengths of the links comply with the conditions: $\overline{AC} = b$, $\overline{GF} = \overline{EH}$, $\overline{GH} = \overline{FE}$, $\overline{EB} : \overline{BH} = \overline{ED} : \overline{HC}$ and $\overline{ED} \times \overline{HC} - \overline{EB} \times \overline{BH} = b^2$. Figure *GFEH* is a crossed-crank linkage. Link *1*, turning about fixed axis *A*, is connected by turning pair *C* to slider *3* which moves along cross-piece *Bd* of slider *4*. Slider *4* moves along fixed guides *p-p* whose axis is parallel to axis *Ox*, and cross-piece *Bd* of slider *4* has its axis parallel to axis *Oy*. Link *5* is connected by turning pairs *E*, *B* and *H* to link *2*, slider *4* and link *6*. Link *6* is connected by turning pairs *C* and *G* to slider *3* and link *7* which, in turn, is connected by turning pair *F* to link *2*. When link *1* turns about axis *A*, point *D* of link *2* describes an apienna with the equation

$$y^2 (x - b)^2 - 2b^3 y + b^4 = 0$$

where *b* is a constant dimension of the mechanism.

| 1215 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING CISSOIDS OF STEINER | LG Ge |
|---|---|---|

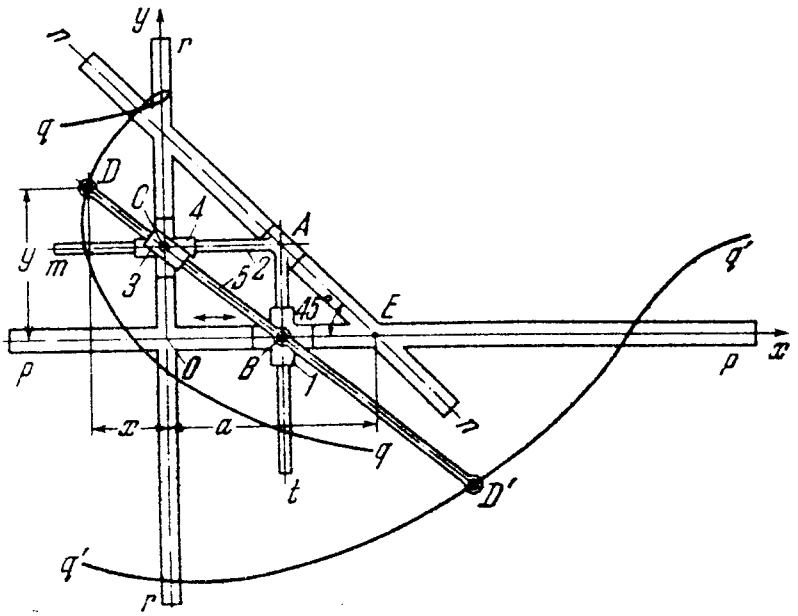



The lengths of the links comply with the conditions: $\overline{EC} = b$, $\overline{OE} = a$, $\overline{OA} = \overline{OB} = \sqrt{a^2 - b^2}$ and $a > b$, where $a$ and $b$ are constant dimensions. Link *1*, turning about fixed axis *E*, is connected by turning pair *C* to slider *6* which moves along stem *Ff* of T-shaped link *3*. Cross-piece *t-t* of link *3* moves in sliders *4* and *9*. Slider *4* turns about fixed axis *B*, and slider *9* is connected by turning pair *D* to slider *2*. Slider *2* moves along axis *Cd* of link *7* which is connected by turning pair *C* to link *6*. Link *7* is connected by a sliding pair to cross-shaped slider *8* which has guides perpendicular to each other. Slider *8* moves along fixed guides *p-p* whose axis coincides with axis *Ox*. When link *1* turns about axis *E*, point *D* of slider *2* describes cissoid of Steiner *q-q* with the equation

$$y^2 [b^2 - (x - a)^2] = [x^2 - (a^2 - b^2)]^2.$$

To trace symmetrical branch $q'$-$q'$ of the cissoid of Steiner, link *1* and slider *6* should be rearranged so that point *C* is moved to point *C'*, lying on stem *Ff*, and that distance $\overline{EC'}$ is equal to $\overline{EC}$.

| 1216 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING DÜRER'S "CONCHOIDS" | LG, Ge |
|---|---|---|

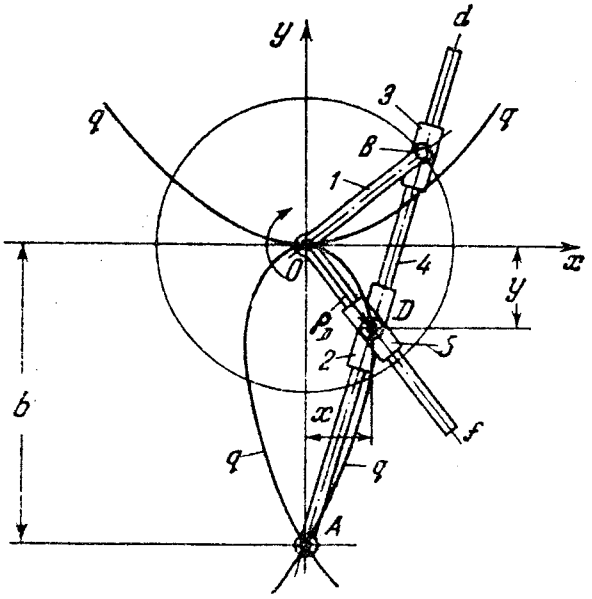



Cross-shaped slider *1*, which has guides perpendicular to each other, moves along fixed guides *p-p* whose axis coincides with axis *Ox*. Slider *2* moves along fixed guides *n-n* whose axis makes the angle 45° with axis *Ox*. Cross-piece *At* of slider *2* has its axis parallel to axis *Oy* and is connected by a sliding pair to slider *1*. Cross-piece *Am* of slider *2* has its axis parallel to axis *Ox* and is connected by a sliding pair to cross-shaped slider *4* which has guides perpendicular to each other. Slider *4* moves along fixed guides *r-r* whose axis coincides with axis *Oy*. Link *5* is connected by turning pair *B* to slider *1* and by a sliding pair to slider *3* which, in turn, is connected by turning pair *C* to slider *4*. When slider *1* moves along guides *p-p*, points *D* and *D'* of link *5* describe branches *q-q* and *q'-q'* of a Dürer "conchoid" with the equation

$$(x - y + a)^2 (b^2 - y^2) = (b^2 - y^2 - xy)^2$$

where $a = \overline{AE}$ and $b = \overline{BD} = \overline{BD'}$ are constant dimensions of the mechanism.

| 1217 | PONCELET LINK-GEAR MECHANISM FOR TRACING CAPRICORNIOIDS | LG Ge |
|---|---|---|




Link *1*, having the form of a bent lever with angle *BOf* equal to 90°, turns about fixed axis *O*. Link *1* is connected by turning pair *B* to slider *3* which moves along axis *Ad* of link *4*. Link *4* turns about fixed axis *A*. Sliders *2* and *5* are connected together by turning pair *D* and move along axes *Ad* and *Of* of links *4* and *1*. When link *1* turns about axis *O*, point *D* of slider *2* describes capricornioid *q-q* with the equation

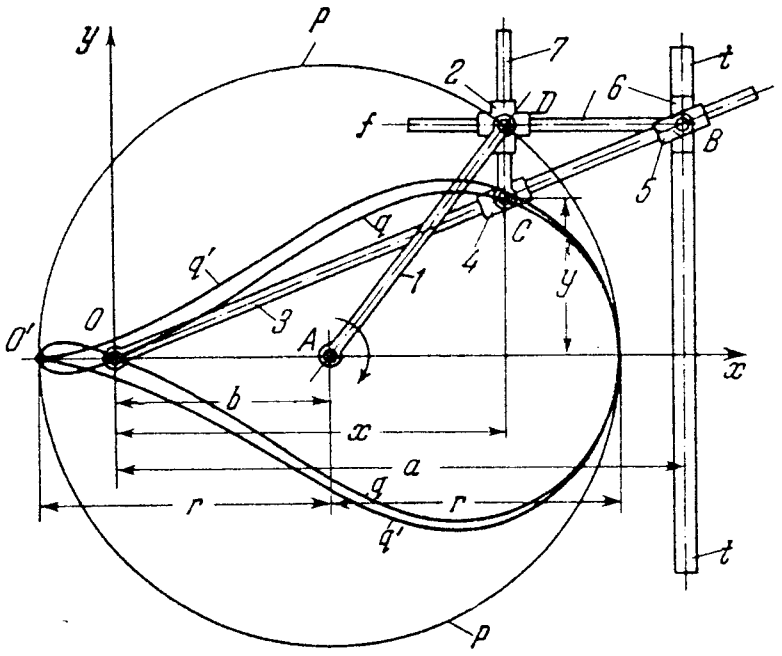
$$\rho_D = \overline{OD} = \frac{ab \sin \varphi}{a + b \cos \varphi}$$

or

$$b^2x^2 (x^2 + y^2) = a^2 (by - x^2 - y^2)^2$$

where $a = \overline{OB}$ = constant dimension of the mechanism
$b = \overline{OA}$ = constant dimension of the mechanism
$\varphi$ = polar angle between vector $\rho_D$ and polar axis *Ox*.

| 1218 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR CONVERTING CIRCLES INTO PIRIFORM CURVES | LG Ge |
|---|---|---|



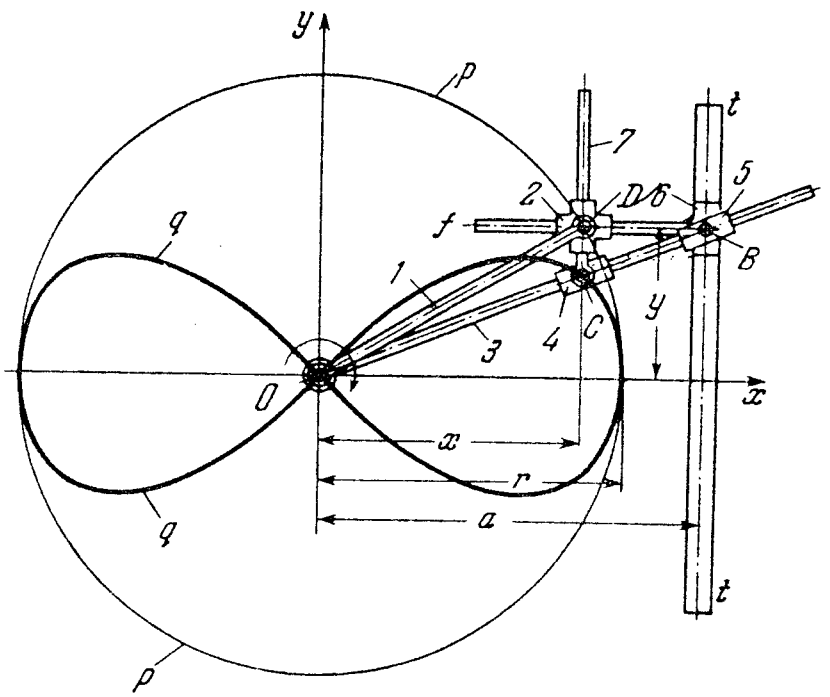

The lengths of the links comply with the condition: $\overline{AD} = r$, where $r$ is the radius of circle $p$-$p$ which is to be converted into a piriform curve. Link *1* turns about fixed axis $A$ and is connected by turning pair $D$ to cross-shaped slider *2* which has guides perpendicular to each other. Link *3* turns about fixed axis $O$ and is connected by sliding pairs to sliders *4* and *5*. Slider *5* is connected by turning pair $B$ to slider *6* which moves along fixed guides $t$-$t$ whose axis is parallel to axis $Oy$. Cross-piece $Bf$ of slider *6* has its axis parallel to axis $Ox$ and is connected by a sliding pair to slider *2*. Link *7* is connected by turning pair $C$ to slider *4* and by a sliding pair to slider *2*. When link *1* turns about axis $A$, point $D$ describes circle $p$-$p$, and point $C$ of slider *4* describes generalized piriform curve $q$-$q$ with the equation

$$x^4 - 2bx^3 - (r^2 - b^2)\, x^2 + a^2y^2 = 0$$

where $a$ and $b$ are constant dimensions of the mechanism. If the axis about which link *3* turns is moved to point $O'$, located on the circle, then point $C$ describes piriform curve $q'$-$q'$ with the equation

$$x^4 - 2bx^3 + a^2y^2 = 0.$$

| 1219 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR CONVERTING CIRCLES INTO CURVES OF SLUZE | LG Ge |
|---|---|---|

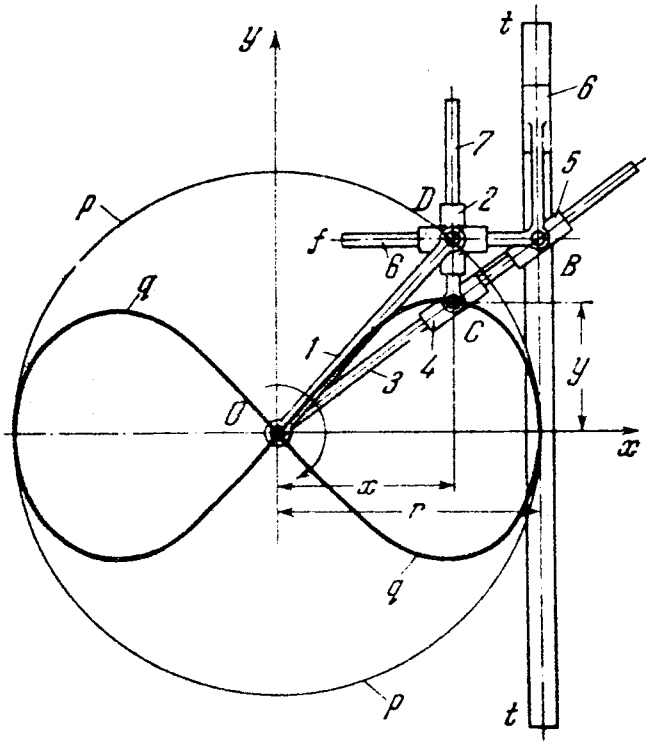



The lengths of the links comply with the condition: $\overline{OD} = r$, where $r$ is the radius of circle $p$-$p$ which is to be converted into a curve of Sluze. Link *1*, turning about fixed axis *O*, is connected by turning pair *D* to cross-shaped slider *2* which has guides perpendicular to each other. Link *3*, turning about axis *O*, is connected by sliding pairs to sliders *4* and *5*. Slider *5* is connected by turning pair *B* to slider *6* which moves along fixed guides *t*-*t* whose axis is parallel to axis *Oy*. Cross-piece *Bf* of slider *6* has its axis parallel to axis *Ox* and is connected by a sliding pair to slider *2*. Link *7* is connected by turning pair *C* to slider *4* and by a sliding pair to slider *2*. When link *1* turns about axis *O*, point *D* of link *2* describes circle *p*-*p*, and point *C* of slider *4* describes curve of Sluze *q*-*q* with the equation

$$x^4 + r^2x^2 + a^2y^2 = 0$$

where $a$ is a constant dimension of the mechanism.

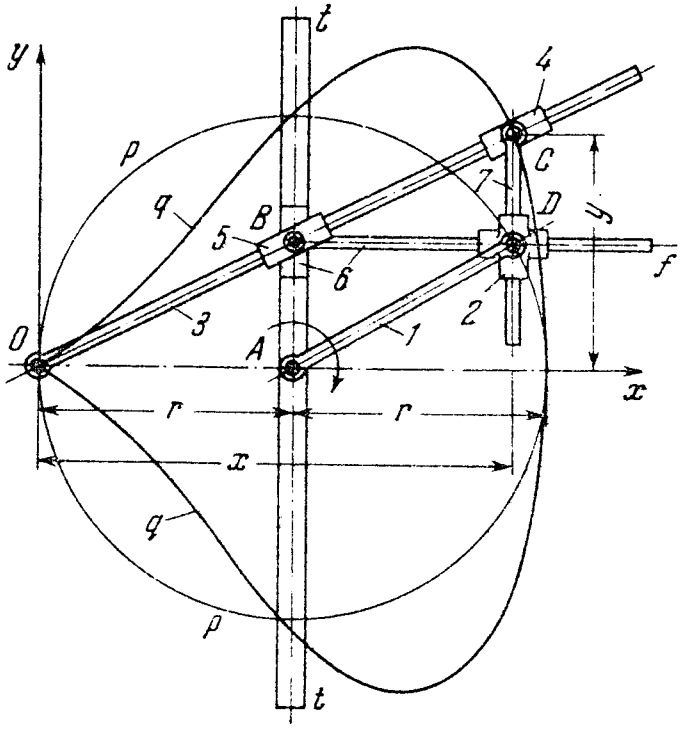
| 1220 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR CONVERTING CIRCLES INTO LEMNISCATES OF GERONO | LG, Ge |
|---|---|---|




The lengths of the links comply with the condition: $\overline{OD} = r$, where $r$ is the radius of circle $p$-$p$ which is to be converted into a lemniscate of Gerono. The axis of guides $t$-$t$ is tangent to circle $p$-$p$. Link *1* turns about fixed axis $O$ and is connected by turning pair $D$ to cross-shaped slider *2* which has guides perpendicular to each other. Link *3* turns about axis $O$ and is connected by sliding pairs to sliders *4* and *5*. Slider *5* is connected by turning pair $B$ to slider *6* which moves along fixed guides $t$-$t$ whose axis is parallel to axis $Oy$. Cross-piece $Bf$ of link *6* has its axis parallel to axis $Ox$ and is connected by a sliding pair to slider *2*. Link *7* is connected by turning pair $C$ to slider *4* and by a sliding pair to slider *2*. When link *1* turns about axis $O$, point $D$ of slider *2* describes circle $p$-$p$ and point $C$ of slider *4* describes lemniscate of Gerono $q$-$q$ with the equation

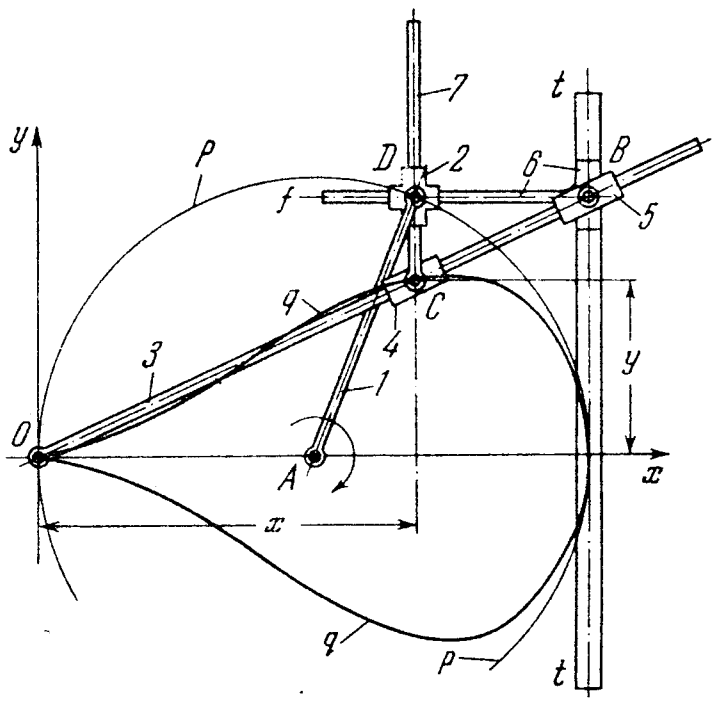
$$x^4 = r^2 (x^2 - y^2).$$

| 1221 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR CONVERTING CIRCLES INTO PIRIFORM CURVES | LG Ge |
|---|---|---|




The lengths of the links comply with the condition: $\overline{OA} = \overline{AD} = r$, where $r$ is the radius of circle $p$-$p$ which is to be converted into a piriform curve. Link *1* turns about fixed axis $A$ and is connected by turning pair $D$ to cross-shaped slider *2* which has guides perpendicular to each other. Link *3* turns about fixed axis $O$ and is connected by sliding pairs to sliders *5* and *4*. Slider *5* is connected by turning pair $B$ to slider *6* which moves along fixed guides $t$-$t$ whose axis is parallel to axis $Oy$ and passes through centre $A$ of circle $p$-$p$. Cross-piece $Bf$ of slider *6* has its axis parallel to axis $Ox$ and is connected by a sliding pair to slider *2*. Link *7* is connected by turning pair $C$ to slider *4* and by a sliding pair to slider *2*. When link *1* turns about axis $A$, point $D$ of slider *2* describes circle $p$-$p$ and point $C$ of slider *4* describes piriform curve $q$-$q$ with the equation

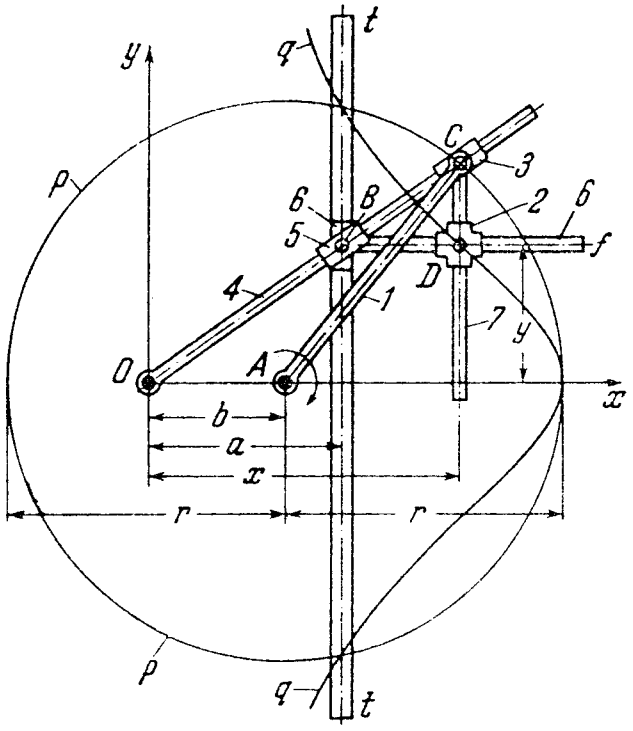
$$x^4 - 2rx^3 + r^2y^2 = 0.$$




The lengths of the links comply with the condition: $\overline{OA} = \overline{AD} = r$, where $r$ is the radius of circle $p$-$p$ which is to be converted into an antiversiera. The axis of guides $t$-$t$ is tangent to circle $p$-$p$. Link *1* turns about fixed axis $A$ and is connected by turning pair $D$ to cross-shaped slider *2* which has guides perpendicular to each other. Link *3* turns about fixed axis $O$ and is connected by sliding pairs to sliders *4* and *5*. Slider *5* is connected by turning pair $B$ to slider *6* which moves along fixed guides $t$-$t$ whose axis is parallel to axis $Oy$. Cross-piece $Bf$ of slider *6* has its axis parallel to axis $Ox$ and is connected by a sliding pair to slider *2*. Link *7* is connected by turning pair $C$ to slider *4* and by a sliding pair to slider *2*. When link *1* turns about axis $A$, point $D$ of slider *2* describes circle $p$-$p$ and point $C$ of slider *4* describes antiversiera $q$-$q$ with the equation

$$x^4 - 2rx^3 + 4r^2y^2 = 0.$$

| 1223 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR CONVERTING CIRCLES INTO FOURTH-ORDER CURVES | LG Ge |
|---|---|---|

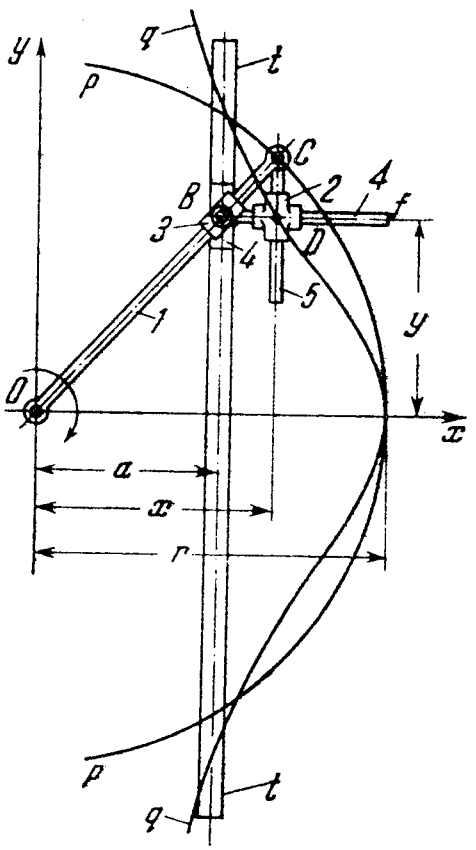



The lengths of the links comply with the condition: $\overline{AC} = r$, where $r$ is the radius of circle $p$-$p$ which is to be converted into a fourth-order curve. Link *1* turns about fixed axis $A$ and is connected by turning pair $C$ to slider *3*. Link *4* turns about fixed axis $O$ and is connected by sliding pairs to sliders *5* and *3*. Slider *5* is connected by turning pair $B$ to slider *6* which moves along fixed guides $t$-$t$ whose axis is parallel to axis $Oy$. Crosspiece $Bf$ of slider *6* has its axis parallel to axis $Ox$ and is connected by a sliding pair to cross-shaped slider *2* which has guides perpendicular to each other. Link *7* is connected by turning pair $C$ to slider *3* and by a sliding pair to slider *2*. When link *1* turns about axis $A$, point $C$ of slider *3* describes circle $p$-$p$ and point $D$ of slider *2* describes fourth-order curve $q$-$q$ with the equation

$$a^2x^2 + x^2y^2 - 2a^2bx = a^2(r^2 - b^2)$$

where $a$ and $b$ are constant dimensions of the mechanism.

| 1224 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR CONVERTING CIRCLES INTO FOURTH-ORDER CURVES | LG Ge |
|---|---|---|

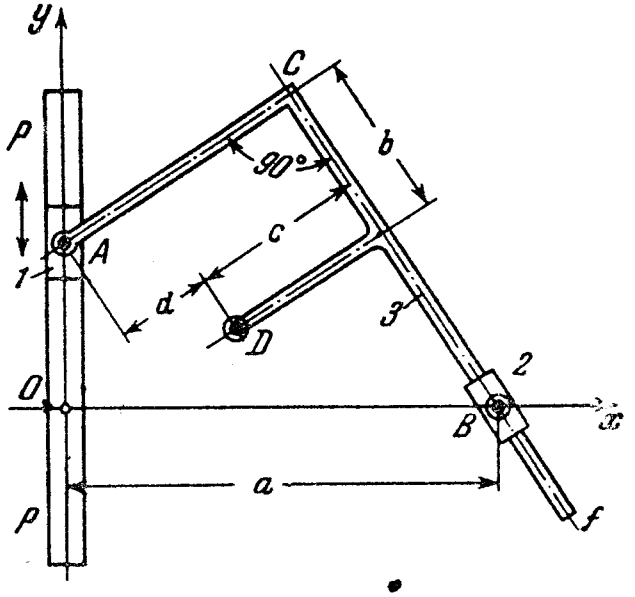



The lengths of the links comply with the condition: $\overline{OC} = r$, where $r$ is the radius of circle $p$-$p$ which is to be converted into a fourth-order curve. Link *1* turns about fixed axis $O$ and is connected by turning pair $C$ to link *5* and by a sliding pair to slider *3*. Link *5* is connected by a sliding pair to cross-shaped slider *2* which has guides perpendicular to each other. Slider *3* is connected by turning pair $B$ to slider *4* which moves along fixed guides $t$-$t$ whose axis is parallel to axis $Oy$. Cross-piece $Bf$ of slider *4* has its axis parallel to axis $Ox$ and is connected by a sliding pair to slider *2*. When link *1* turns about axis $O$, point $C$ of link *1* describes circle $p$-$p$ and point $D$ of slider *2* describes fourth-order curve $q$-$q$ with the equation

$$x^2 (a^2 \quad a^2 r^2$$

where $a$ is a constant dimension of the mechanism.

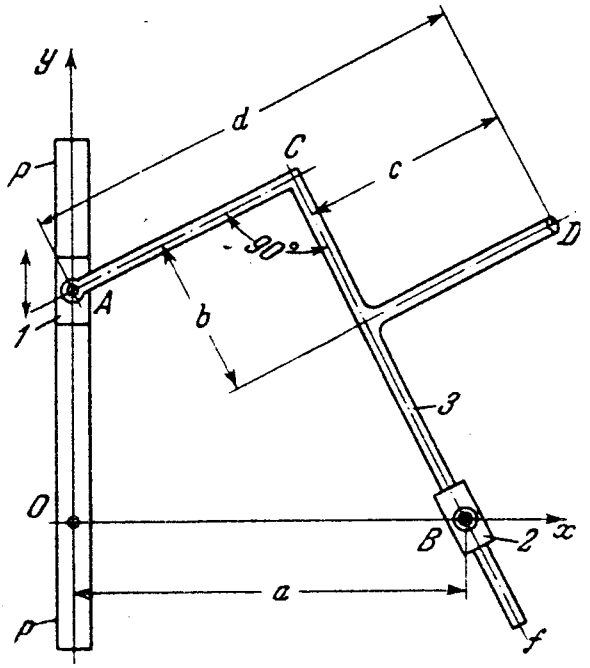
| 1225 | NEUBERG-POLYNOVSKY LINK-GEAR MECHANISM FOR TRACING FOURTH-ORDER CURVES | LG Ge |
|---|---|---|




Slider *1* moves along fixed guides *p-p* whose axis coincides with axis *Oy*. Link *3* has the form of a bent lever with angle *ACf* equal to 90° and is connected by turning pair *A* to slider *1*. Arm *Cf* of link *3* moves in slider *2* which turns about fixed axis *B*. When slider *1* moves along guides *p-p*, point *D* of link *3* describes a fourth-order algebraic curve with the equation

$$(x^2 - ax + cd)^2 + (yx - bc)^2 = (ab + dy - bx)^2$$

where *a*, *b*, *c* and *d* are constant dimensions of the mechanism. When $a = \overline{AC}$, point *D* describes an algebraic curve of the third order.

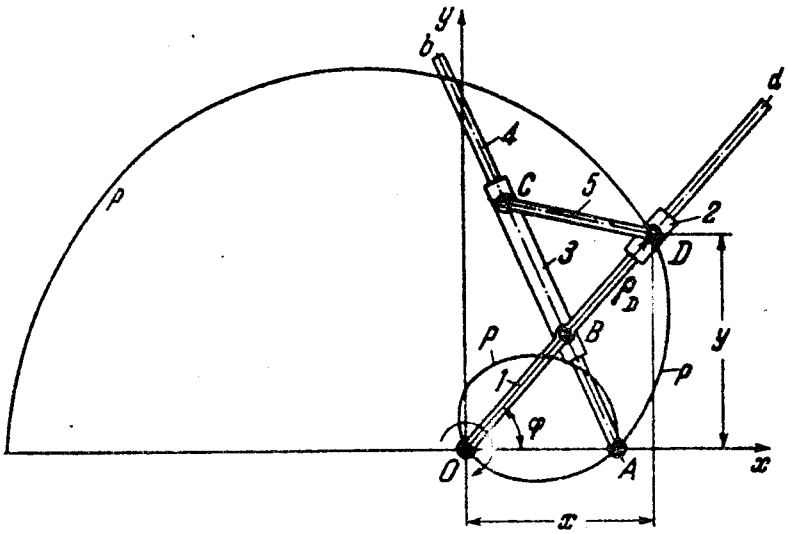



Slider *1* moves along fixed guides *p-p* whose axis coincides with axis *Oy*. Link *3* has the form of a bent lever with angle *ACf* equal to 90° and is connected by turning pair *A* to slider *1*. Arm *Cf* of link *3* moves in slider *2* which turns about fixed axis *B*. When slider *1* moves along guides *p-p*, point *D* of link *3* describes a fourth-order algebraic curve with the equation

$$(x^2 - ax + cd)^2 + (yx + bc)^2 = (ab + dy - bx)^2$$

where *a*, *b*, *c* and *d* are constant dimensions of the mechanism. When $a = \overline{AC}$, point *D* describes an algebraic curve of the third order.

| 1227 | LINK-GEAR MECHANISM FOR TRACING NEPHROIDS | LG Ge |
|---|---|---|




The lengths of the links comply with the condition: $\overline{OB} = a$. Link *1* turns about fixed axis *O* and is connected by turning pair *B* to slider *3* which, in turn, moves along axis *Ab* of link *4*. Link *4* turns about fixed axis *A*. Link *5* is connected by turning pairs *C* and *D* to sliders *3* and *2*. Slider *2* moves along axis *Od* of link *1*. When link *1* turns about axis *O*, point *D* of slider *2* describes nephroid *p-p* with the equation

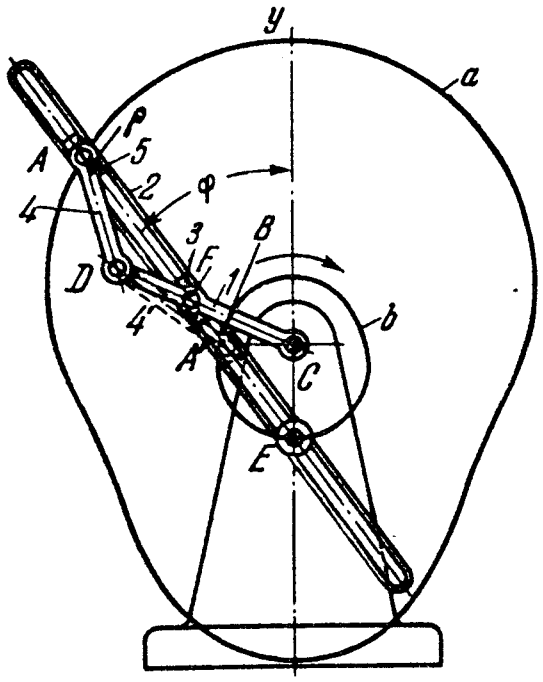
$$\rho_D = \overline{OD} = a\left(1 + 2\sin\frac{\varphi}{2}\right)$$

or

$$(x^2 + y^2)\,(x^2 + y^2 - a^2)^2 = 4a^2\,(x^2 + y^2 - ax)^2$$

where $\varphi$ is the polar angle between vector $\rho_D$ and polar axis *Ox*.

| 1228 | LINK-GEAR MECHANISM FOR TRACING CRANIOIDS | LG Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AD} = \overline{CF} = \overline{EA'}$ and $\overline{CF} > \overline{CE}$. Link *1* turns about fixed axis *C*. Slotted link *2* turns about fixed axis *E*. Slider *3*, moving along the slot of link *2*, is connected by turning pair *F* to link *1*. Link *4* is connected by turning pairs *D* and *A* to link *1* and slider *5* which moves along the slot of link *2*. When link *1* turns about axis *C*, points *A* and *A'* describe a cranioid consisting of branches *a* and *b* with the polar equation

$$\rho = d\cos\varphi + b\sqrt{1 - m^2\sin^2\varphi} + c\sqrt{1 - k^2\sin^2\varphi}$$

where $\rho = \overline{EA}$

$d = \overline{EC}$

$b = \overline{CD}$

$c = \overline{AD} = \overline{CF}$

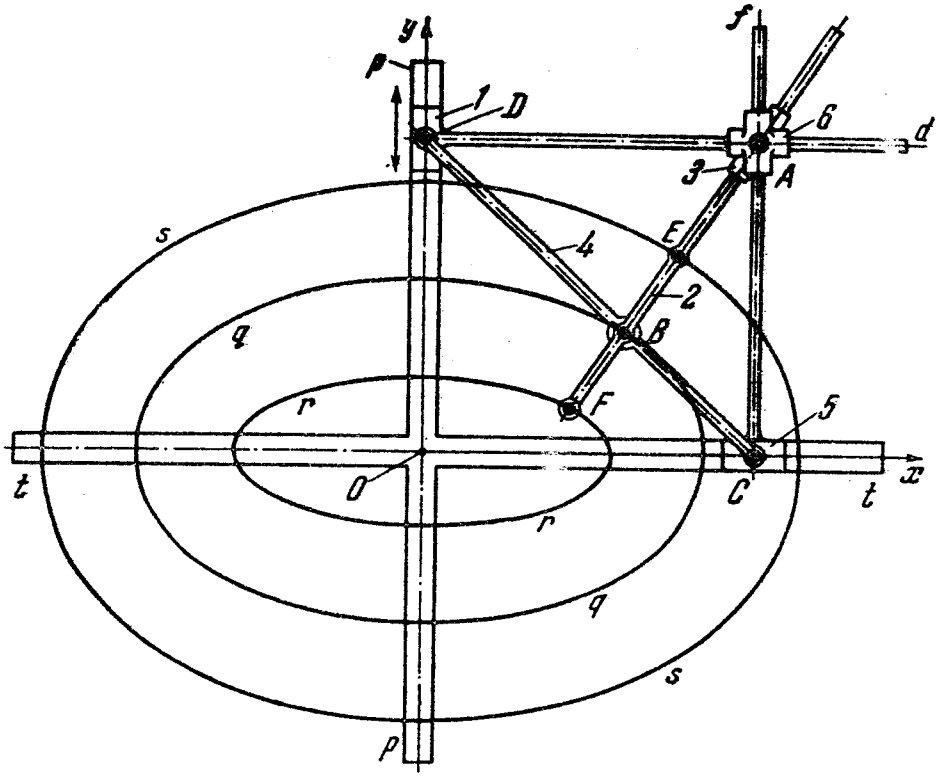
$m = \dfrac{\overline{EC}}{\overline{FC}}$

$k = m\dfrac{\overline{FD}}{\overline{AD}}$

$\varphi$ = angle between vector $\rho$ and axis $Ey$.

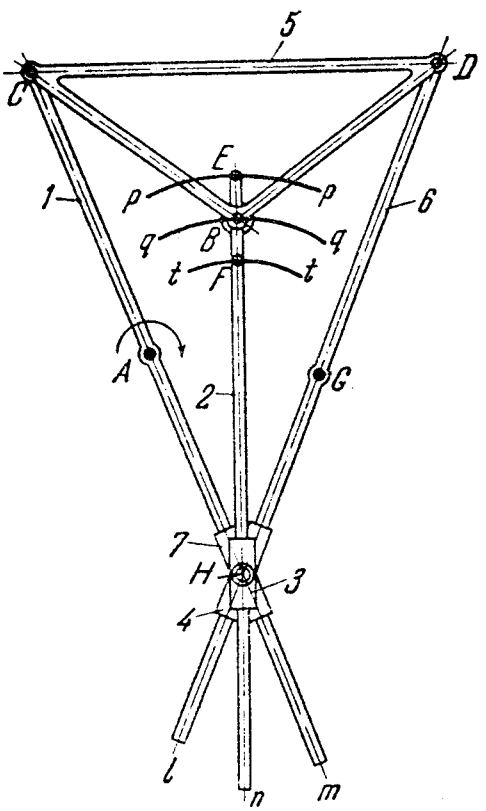
In the indicated position of link *AD*, point *A* describes the first branch *a* of the cranioid. If link *4* is put into position *4'* (shown by dash lines), point *A'* describes the second branch *b* of the cranioid which is self-intersecting at point *E*.

| 1229 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING EQUIDISTANT CURVES OF ELLIPSES | LG Ge |
|---|---|---|




The lengths of the inks comply with the conditions: $\overline{BD} = a$ and $\overline{BC} = b$, where $a$ and $b$ are semiaxes of ellipse $q$-$q$. Slider *1* moves along fixed guides $p$-$p$ whose axis coincides with axis $Oy$. Slider *1* is connected by turning pair $D$ to link *4* which, in turn, is connected by turning pair $C$ to slider *5*. Slider *5* moves along fixed guides $t$-$t$ whose axis coincides with axis $Ox$. Sliders *1* and *5* have cross-pieces $Dd$ and $Cf$ whose axes are parallel to axes $Ox$ and $Oy$. These cross-pieces are connected by sliding pairs to cross-shaped slider *6* which has guides perpendicular to each other. Link *2* is connected by turning pair $B$ to link *4* and by a sliding pair to slider *3* which, in turn, is connected by turning pair $A$ to link *6*. When slider *1* moves along guides $p$-$p$, point $B$ of link *2* describes ellipse $q$-$q$. The equidistant curves $s$-$s$ and $r$-$r$ are described by points $E$ and $F$ of link *2*.

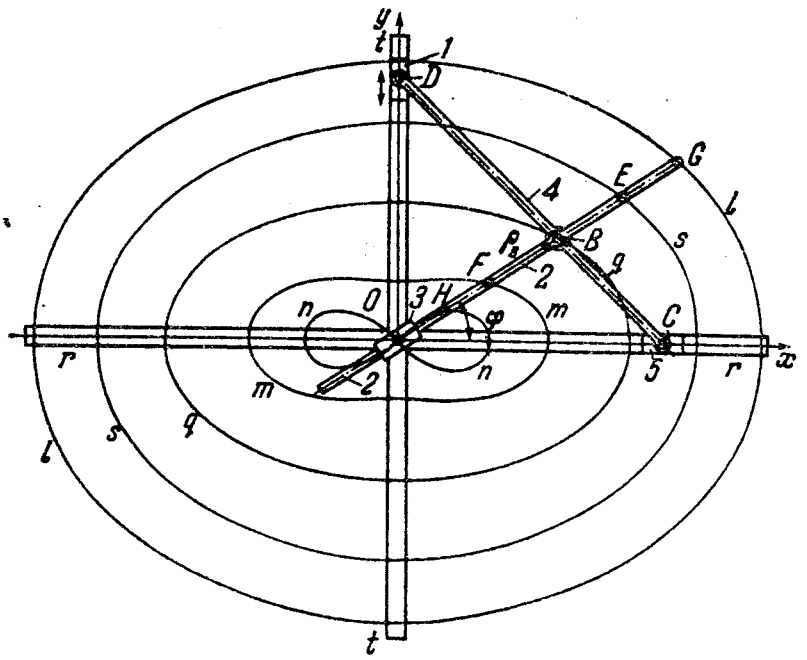
| 1230 | LINK-GEAR MECHANISM FOR TRACING EQUIDISTANT CURVES OF CONNECTING-ROD CURVES OF FOUR-BAR LINKAGES | LG Ge |
|---|---|---|




The mechanism is based on four-bar linkage *ACDG*. Point *B* of connecting rod *5* of the linkage describes connecting-rod curve *q-q*. Links *1* and *6* are connected by sliding pairs to sliders *7* and *4*, which are connected together by turning pair *H*. Link *2* is connected by turning pair *B* to connecting rod *5* and by a sliding pair to slider *3* which, in turn, is connected by turning pair *H* to sliders *4* and *7*. When link *1* turns about fixed axis *A*, any point of link *2*, lying on axis *EBH*, describes an equidistant curve of connecting-rod curve *q-q*. The equidistant curves *p-p* and *t-t* are described by points *E* and *F* of link *2*.

## 1231 LINK-GEAR MECHANISM FOR TRACING CURVES OF DISTORTED ELLIPSES

LG
Ge



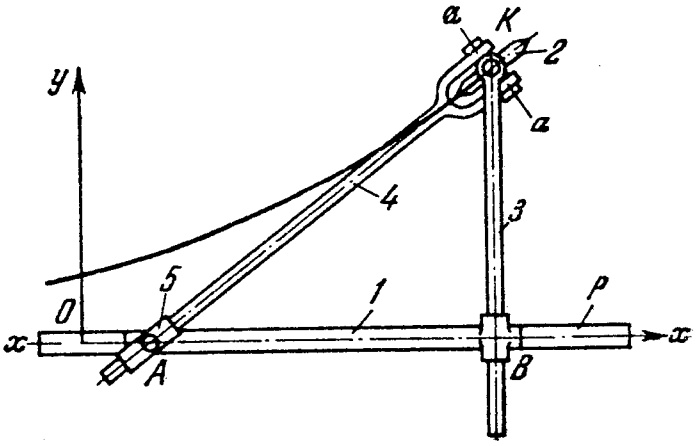

The lengths of the links comply with the conditions: $\overline{BD} = a$ and $\overline{BC} = b$, where $a$ and $b$ are the semiaxes of ellipse $q$-$q$. Slider *1* moves along fixed guides $t$-$t$ whose axis coincides with axis $Oy$. Slider *1* is connected by turning pair $D$ to link *4* which, in turn, is connected by turning pairs $B$ and $C$ to links *2* and slider *5*. Slider *5* moves along fixed guides $r$-$r$ whose axis coincides with axis $Ox$. Link *2* is connected by a sliding pair to slider *3* which turns about fixed axis $O$. When slider *1* moves along guides $t$-$t$, point $B$ of link *2* describes ellipse $q$-$q$ with the equation

$$\rho_B = \overline{OB} = \sqrt{\frac{a^2 b^2}{b^2 \cos^2 \varphi + a^2 \sin^2 \varphi}}$$

where $\varphi$ is the polar angle between vector $\rho_B$ and polar axis $Ox$. Any other point of link *2*, lying on its axis, describes a curve which will be the curve of a distorted ellipse with respect to the radius vector having its origin at the centre of the ellipse. Curves $l$-$l$, $s$-$s$, $m$-$m$ and $n$-$n$ are described by points $G$, $E$, $F$ and $H$ of link *2*. The polar equation for any point $K$, located along the axis of link *2* at the distance $d$ from point $B$, is

$$\rho_K = \rho_B \pm d.$$

| 1232 | LINK-GEAR MECHANISM FOR TRACING LOGARITHMIC OR EXPONENTIAL CURVES | LG Ge |
|---|---|---|

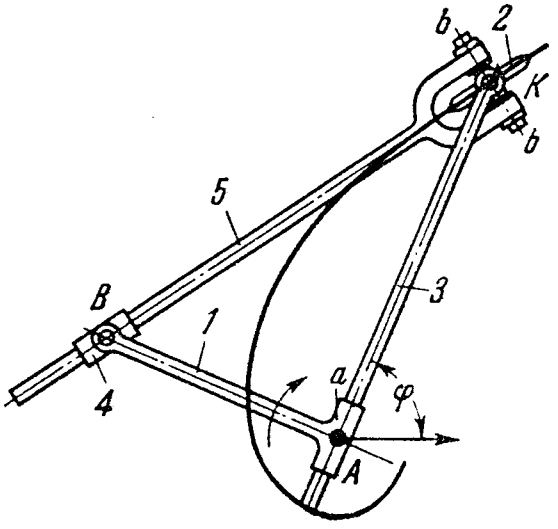



Cross-shaped slider *1* nas guides perpendicular to ach other and moves along fixed guides *p*. Link *3* moves in slider *1* and is connected by turning pair *K* to link *4*. Link *4* moves in slider *5* which is connected by turning pair *A* to slider *1*. Roller *2* has a sharp-edged rim and rotates about axis *a-a*. When slider *1* moves along axis *x-x* of guide *p*, roller *2*, cutting into the surface of the drawing with its sharp edge, moves during each instant along straight line *AK*. Link *3* moves in a direction perpendicular to axis *x-x*. The envelope of the successive positions of straight line *AK* is a logarithmic or exponential curve with the equation

$$y = ke^{ax}$$

where $a = \overline{AB}$
$k$ = value of ordinate $y$ at $x = 0$
$e$ = base of natural logarithms.

| 1233 | VYATKIN LINK-GEAR MECHANISM FOR TRACING HYPERBOLIC SPIRALS | LG Ge |
|---|---|---|




Link *1* turns about fixed axis *A* and is connected by turning pair *B* to slider *4* which, in turn, moves along the axis of link *5*. Link *3* is connected by turning pair *K* to link *5* and slides in guide *a* of link *1*. The axis of guide *a* is perpendicular to line *AB*. Roller *2* has a sharp-edged rim and rotates about axis *b-b*. When link *1* turns about axis *A*, roller *2*, cutting into the surface of the drawing with its sharp edge, moves during each instant along the straight line *BK*. The envelope of the successive positions of straight line *BK* is a hyperbolic spiral with the polar equation, with respect to pole *A*,

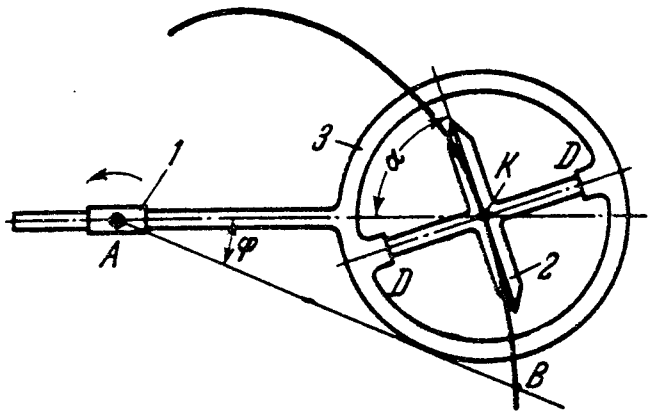
$$\rho\varphi = a$$

where $\rho = \overline{AK}$

$a = \overline{AB}$

$\varphi$ = angle of rotation of radius vector $\rho$.

| 1234 | FOUR-BAR SLIDING-LINK MECHANISM FOR TRACING LOGARITHMIC SPIRALS | LG-Ge |
|---|---|---|

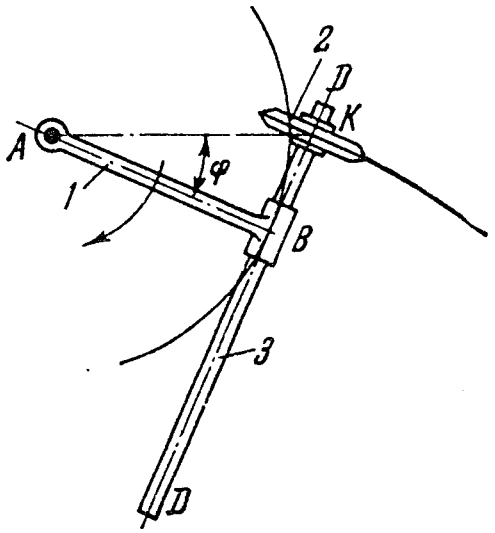



Slider *1* turns about fixed axis *A*. Link *3* moves in slider *1*. Roller *2* rotates about axis *D-D*. When slider *1* turns about axis *A*, roller *2*, cutting into the surface of the drawing with its sharp edge, moves during each instant along a straight line coinciding with the plane of the roller. The envelope of the successive positions of this straight line is a logarithmic spiral with the polar equation, with respect to pole *A*,

$$\rho = ae^{\varphi/\tan\alpha}$$

where $\rho = \overline{AK}$
$\varphi$ = angle of rotation of radius vector $\rho$
$a = \overline{AB}$ = initial value of the radius vector
$e$ = base of natural logarithms
$\alpha$ = angle between axis $AK$ and the plane of roller *2*.

| 1235 | FOUR-BAR SLIDING-LINK MECHANISM FOR TRACING INVOLUTES | LG Ge |
|---|---|---|




Link *1* turns about fixed axis *A* and is connected by sliding pair *B* to link *3*. Roller *2* rotates about axis *D-D*. When link *1* turns about axis *A*, roller *2*, cutting into the surface of the drawing with its sharp edge, moves during each instant along the line of intersection of the planes of the drawing and of roller *2*. The envelope of the successive positions of this straight line is an involute with the polar equation, with respect to pole *A*,

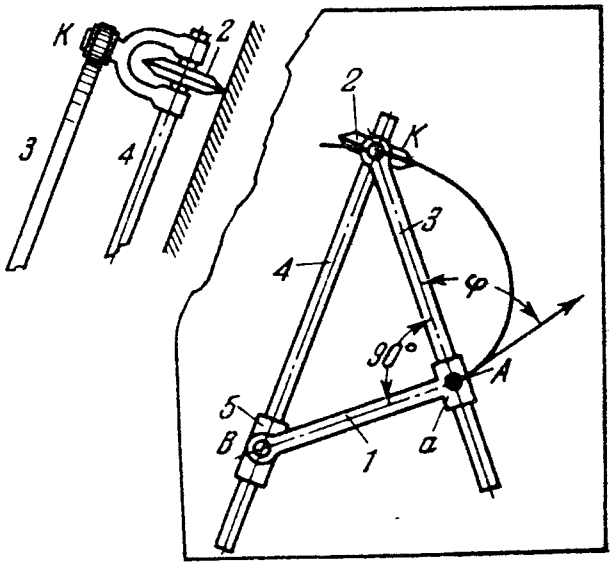
$$R = a\varphi$$

where $R = \overline{BK}$

$a = \overline{AB}$

$\varphi$ = angle of rotation of link *1*.

| 1236 | VYATKIN LINK-GEAR MECHANISM FOR TRACING SPIRALS OF ARCHIMEDES | LG Ge |
|---|---|---|




Link *1* turns about fixed axis *A* and is connected by turning pair *B* to slider *5* which, in turn, moves along the axis of link *4*. Link *3* is connected by turning pair *K* to link *4* and slides in guide *a* of link *1*. The axis of guide *a* is perpendicular to line *BA*. Roller *2* has a sharp-edged rim and rotates about the axis of link *4*. When link *1* turns about axis *A*, roller *2*, cutting into the surface of the drawing with its sharp edge, moves during each instant along the line of intersection of the planes of the drawing and of roller *2*. The envelope of the successive positions of roller *2* is a spiral of Archimedes with the polar equation, with respect to pole *A*,

$$\rho = b\,(\varphi + \varphi_0)$$

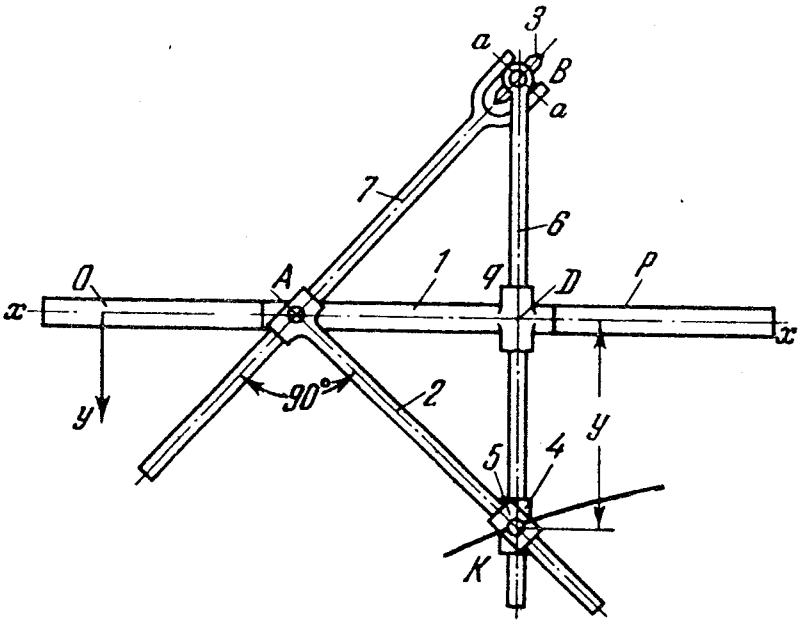
where $b = \overline{AB}$

$\rho = \overline{AK}$

$\varphi$ = angle of rotation of radius vector $\rho$

$\varphi_0$ = initial angle.

| 1237 | VYATKIN LINK-GEAR MECHANISM FOR TRACING EXPONENTIAL CURVES | LG Ge |
|---|---|---|




Cross-shaped slider *1* has guides with axes perpendicular to each other and moves along fixed guides *p*. Slider *1* is connected by turning pair *A* to link *2* which slides along the axis of link *7*. Link *7* is connected by turning pair *B* to link *6* which, in turn, slides in guide *q* of slider *1*. Links *4* and *5* are connected together by turning pair *K* and slide along the axes of links *6* and *2*. Roller *3* has a sharp-edged rim and rotates about axis *a-a*. When slider *1* moves along axis *x-x* of guides *p*, roller *3*, cutting into the surface of the drawing with its sharp edge, moves during each instant along straight line *AB*. Sliding link *2*, whose axis is perpendicular to line *AB*, turns and point *K* describes an exponential curve with the equation

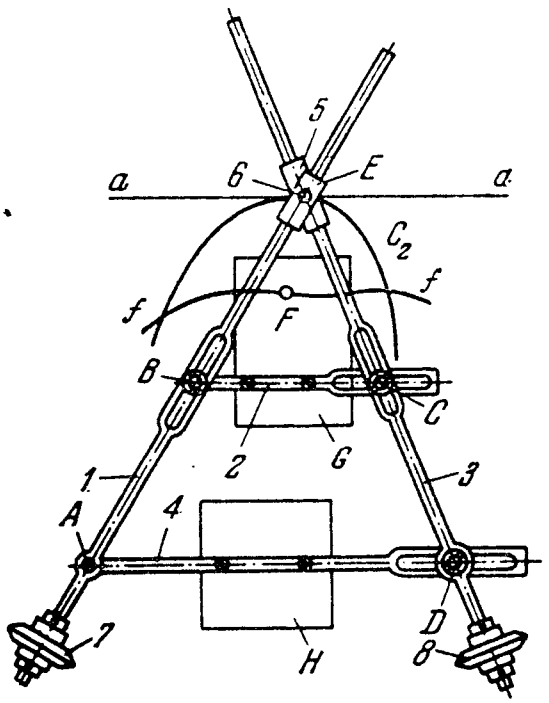
$$y = be^{-ax}$$

where $a = \overline{AD}$

$b$ = value of ordinate $y$ at $x = 0$

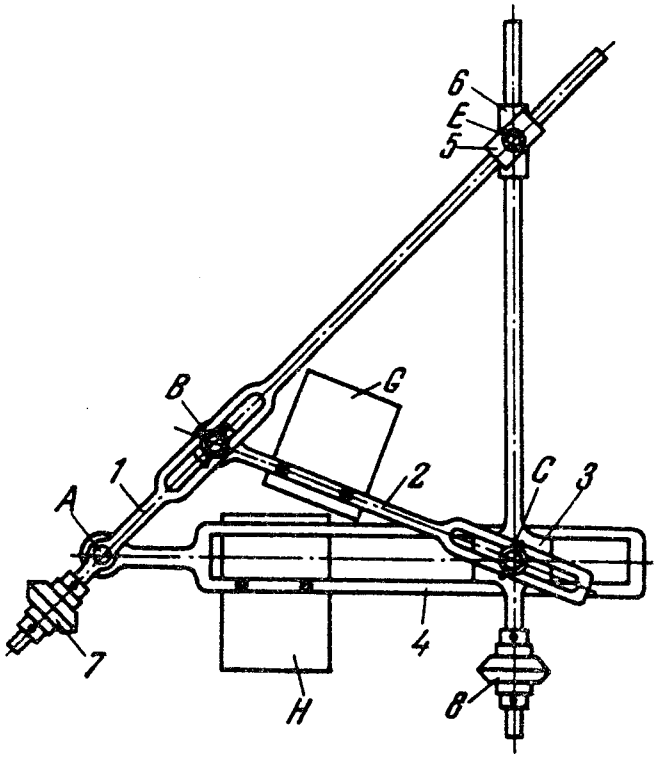
$e$ = base of natural logarithms.

| 1238 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING ROULETTES OF THE CENTRODES OF FOUR-BAR LINKAGES | LG, Ge |
|---|---|---|



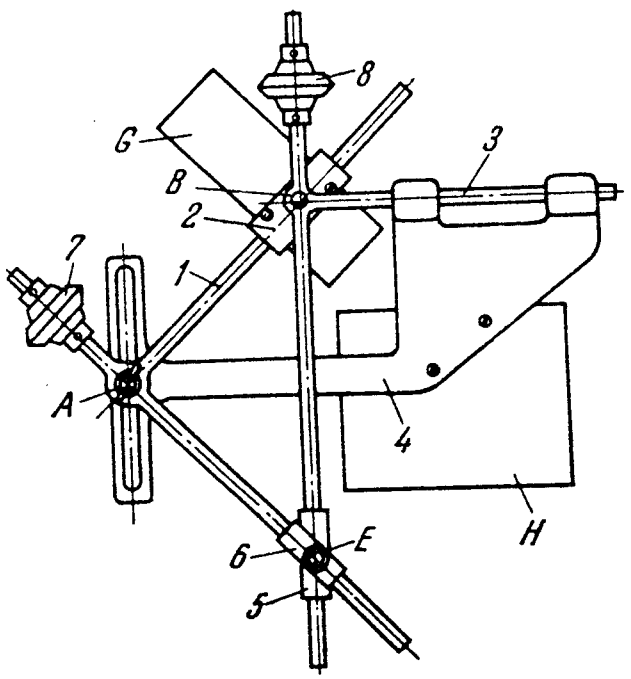

The mechanism is based on four-bar linkage *ABCD*. Added to this linkage is a double guiding element consisting of two sliders, *5* and *6*, connected together by turning pair *E*. Links *1* and *3* have wheels *7* and *8* with sharp-edged rims which can only rotate about their axes. The mechanism is intended for tracing the roulettes of the centrodes of links *2* and *4*. For this purpose, a stylus at the centre of pivot *E* is placed on the curve with respect to which the roulette of the centrode of link *2* or *4* is to be obtained. Wheels *7* and *8* are set on a plane table. When the stylus of pivot *E* is moved along the above-mentioned curve so that wheels *7* and *8* roll along the plane table, any point of plane members *G* and *H*, attached respectively to links *2* and *4*, describes the corresponding roulette of the centrode of link *2* or link *4*. Shown is roulette *f-f* of centrode $C_2$ of link *2*. It is described by point *F* of link *2* when the stylus of pivot *E* is moved along straight line *a-a*. This corresponds to the rolling of body centrode $C_2$ along straight line *a-a*. The mechanism can be set up for various centrodes by adjusting pivots *B*, *C* and *D* along the corresponding slots as required.

| 1239 | ARTOBOLEVSKY SLIDING-LINK MECHANISM FOR TRACING ROULETTES OF THE CENTRODES OF SLIDER-CRANK LINKAGES | LG Ge |
|---|---|---|




The mechanism is based on slider-crank linkage *ABC*. Added to this linkage is a double guiding element consisting of two sliders, *5* and *6*, connected together by turning pair *E*. Links *1* and *3* have wheels *7* and *8* with sharp-edged rims, which can only rotate about their axes. The mechanism is intended for tracing the roulettes of the centrodes of links *2* and *4*. For this purpose, a stylus at the centre of pivot *E* is placed on the curve with respect to which the roulette of the centrode of link *2* or *4* is to be obtained. Wheels *7* and *8* are set on a plane table. When the stylus of pivot *E* is moved along the above-mentioned curve so that wheels *7* and *8* roll along the plane table, any point of plane members *G* and *H*, attached respectively to links *2* and *4*, describes the corresponding roulette of the centrode of link *2* or link *4*. The mechanism can be set up for various centrodes by adjusting pivots *B* and *C* along the corresponding slots as required.

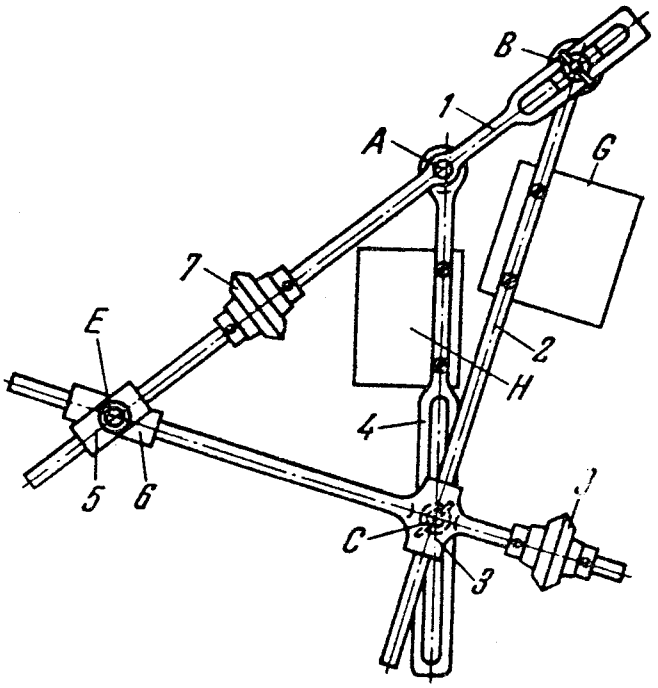
| 1240 | ARTOBOLEVSKY SLIDING-LINK MECHANISM FOR TRACING ROULETTES OF THE CENTRODES OF TANGENT GENERATORS | LG Ge |
|---|---|---|




The mechanism is based on a tangent generator consisting of links *1*, *2*, *3* and *4*. Added to this linkage is a double guiding element consisting of two sliders, *5* and *6*, connected together by turning pair *E*. Links *1* and *3* have wheels *7* and 8 with sharp-edged rims, which can only rotate about their axes. The mechanism is intended for tracing the roulettes of the centrodes of links *2* and *4*. For this purpose, a stylus at the centre of pivot *E* is placed on the curve with respect to which the roulette of the centrode of link *2* or *4* is to be obtained. Wheels *7* and *8* are set on a plane table. When the stylus of pivot *E* is moved along the above-mentioned curve so that wheels *7* and *8* roll along the plane table, any point of plane members *G* and *H*, attached respectively to links *2* and *4*, describes the corresponding roulette of the centrode of link *2* or link *4*. The mechanism can be set up for various centrodes by adjusting pivot *A* along the slot of link *4*.

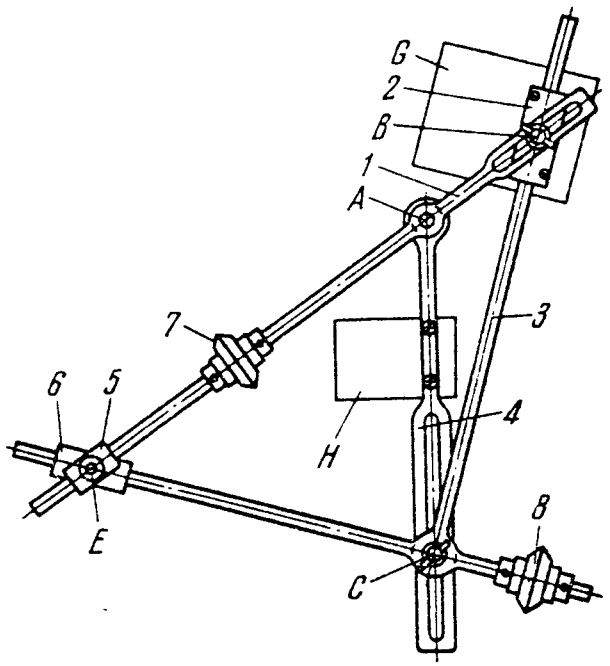
LG
Ge

| 1241 | ARTOBOLEVSKY SLIDING-LINK MECHANISM FOR TRACING ROULETTES OF THE CENTRODES OF OSCILLATING SLIDER LINKAGES | LG Ge |
|---|---|---|



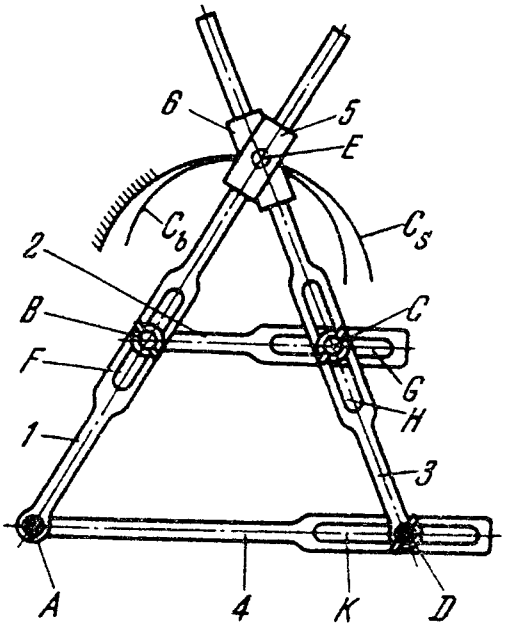

The mechanism is based on sliding link mechanism *ABC* with oscillating slider *3*. Added to this linkage is a double guiding mechanism consisting of two sliders, *5* and *6*, connected together by turning pair *E*. Links *1* and *3* have wheels *7* and *8* with sharp-edged rims, which can only rotate about their axes. The mechanism is intended for tracing the roulettes of the centrodes of links *2* and *4*. For this purpose, a stylus at the centre of pivot *E* is placed on the curve with respect to which the roulette of the centrode of link *2* or *4* is to be obtained. Wheels *7* and *8* are set on a plane table. When the stylus of pivot *E* is moved along the above-mentioned curve so that wheels *7* and *8* roll along the plane table, any point of plane members *G* and *H*, attached respectively to links *2* and *4*, describes the corresponding roulette of the centrode of link *2* or link *4*. The mechanism can be set up for various centrodes by adjusting pivots *B* and *C* along the corresponding slots as required.

| 242 | ARTOBOLEVSKY SLIDING-LINK MECHANISM FOR TRACING ROULETTES OF THE CENTRODES OF SLIDING-LINK MECHANISMS | LG Ge |
|---|---|---|



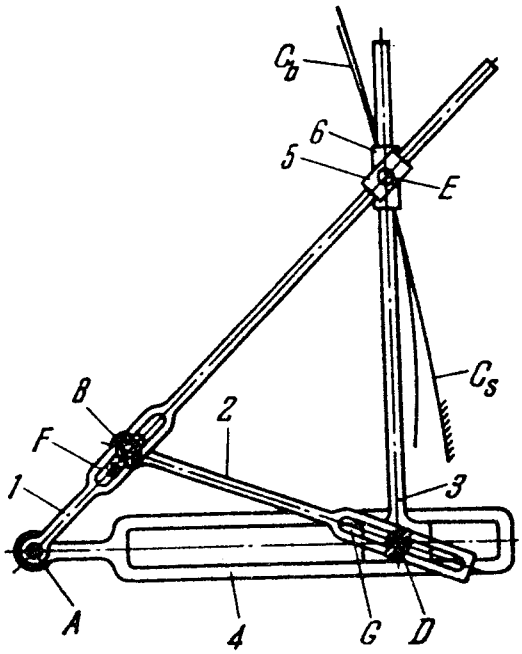

The mechanism is based on sliding-link mechanism *ABC* with oscillating sliding link *3*. Added to this linkage is a double guiding element consisting of two sliders, *5* and *6*, connected together by turning pair *E*. Links *1* and *3* have wheels *7* and *8* with sharp-edged rims, which can only rotate about their axes. The mechanism is intended for tracing the roulettes of the centrodes of links *2* and *4*. For this purpose, a stylus at the centre of pivot *E* is placed on the curve with respect to which the roulette of the centrode of link *2* or *4* is to be obtained. Wheels *7* and *8* are set on a plane table. When the stylus of pivot *E* is moved along the above-mentioned curve, any point of plane members *G* and *H*, attached respectively to links *2* and *4*, describes the corresponding roulette of the centrode of link *2* or link *4*. The mechanism can be set up for various centrodes by adjusting pivots *B* and *C* along the corresponding slots as required.

| 1243 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING CENTRODES OF FOUR-BAR LINKAGES | LG Ge |
|---|---|---|



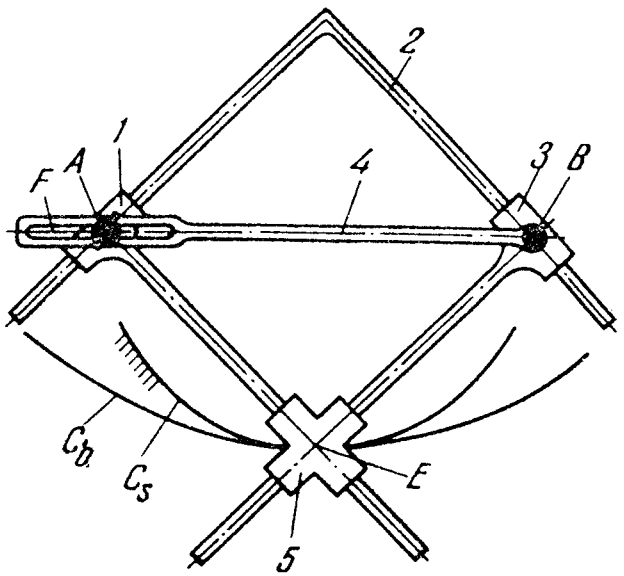

The mechanism is based on four-bar linkage *ABCD*. Added to this linkage is a double guiding element consisting of two sliders, *5* and *6*, connected together by turning pair *E*. The mechanism is intended for tracing the centrodes of links *2* and *4*. The tracing stylus is at the centre of pivot *E*. In the shown position, the mechanism is set up for tracing space centrode $C_s$, i.e. for the case when pivots *A* and *D* are fixed. To trace body centrode $C_b$, pivots *B* and *C* are fixed and pivots *A* and *D* are released. The required centrodes can be obtained by varying the lengths of links *1*, *2*, *3* and *4*. This is accomplished by adjusting pivots *B*, *C* and *D* along slots *F*, *G*, *H* and *K* in links *1*, *2*, *3* and *4*.

| 1244 | ARTOBOLEVSKY SLIDING-LINK MECHANISM FOR TRACING CENTRODES OF SLIDER-CRANK LINKAGES | LG Ge |
|---|---|---|



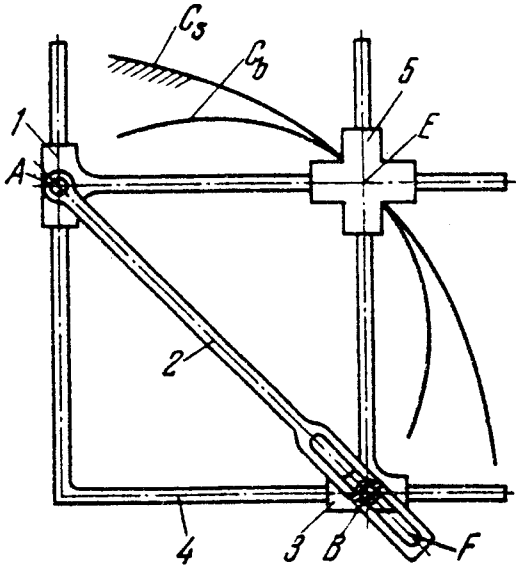

The mechanism is based on slider-crank linkage *ABC*. Added to this linkage is a double guiding element consisting of two sliders, *5* and *6*, connected together by turning pair *E*. The mechanism is intended for tracing the body and space centrodes of links *2* and *4*. The tracing stylus is at the centre of pivot *E*. The mechanism is shown set up for tracing space centrode $C_s$, i.e. for the case when link *4* is fixed. To trace the body centrode $C_b$, pivots *B* and *C* are secured to the fixed plane, and link *4* is released. Centrodes of various shapes can be obtained by varying the lengths of links *1* and *2*. This is accomplished by adjusting pivots *B* and *C* in slots *F* and *G* of links *1* and *2*.

| 1245 | ARTOBOLEVSKY SLIDING-LINK MECHANISM FOR TRACING CENTRODES OF DOUBLE OSCILLATING SLIDER LINKAGES | LG Ge |
|---|---|---|



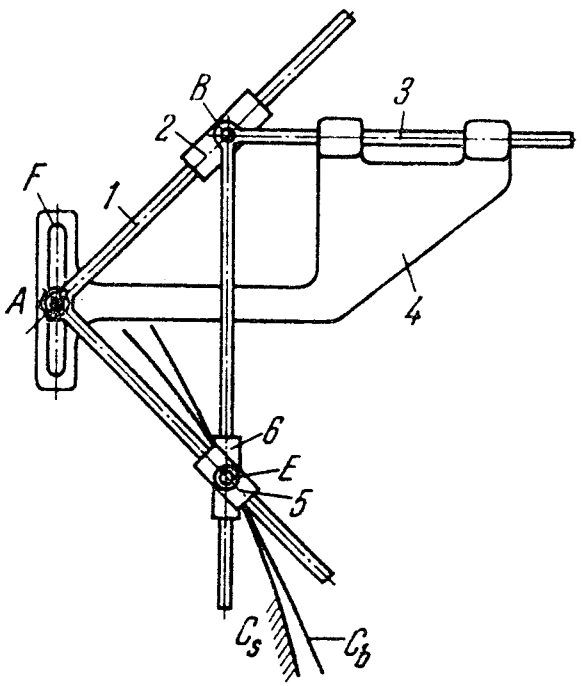

The mechanism is based on a sliding-link mechanism with two sliders oscillating about axes *A* and *B*, and consists of links *1*, *2*, *3* and *4*. Added to this linkage is cross-shaped slider *5*. The mechanism is intended for tracing body and space centrodes of links *2* and *4*. The tracing stylus is at centre *E* of slider *5*. The mechanism is shown set up for tracing space centrode $C_s$. To trace body centrode $C_b$, link *2* is secured to the fixed plane, and link *4* is released. Centrodes of various shapes can be obtained by varying the distance between pivots *A* and *B*. This is accomplished by adjusting pivot *A* along slot *F* of link *4*.

| 1246 | ARTOBOLEVSKY SLIDING-LINK MECHANISM FOR TRACING CENTRODES OF ELLIPSOGRAPH MECHANISMS | LG Ge |
|---|---|---|



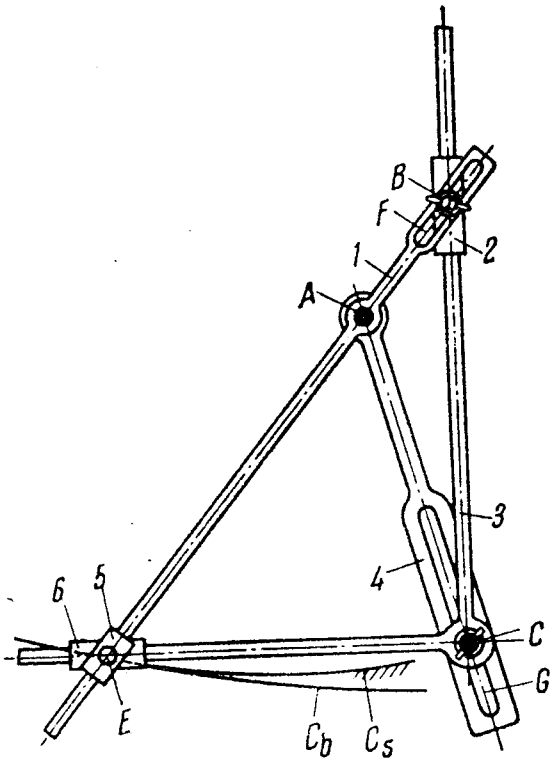

The mechanism is based on the sliding-link mechanism of an ellipsograph consisting of links *1*, *2*, *3* and *4*. Added to this linkage is cross-shaped slider *5*. The mechanism is intended for tracing body and space centrodes of links *2* and *4*. The tracing stylus is at centre *E* of slider *5*. The mechanism is shown set up for tracing space centrode $C_s$. To trace body centrode $C_b$, link *2* is secured to the fixed plane and link *4* is released. Centrodes of various shapes can be obtained by varying the distance between pivots *A* and *B*. This is accomplished by adjusting pivot *B* along slot *F* of link *2*.

| 1247 | ARTOBOLEVSKY SLIDING-LINK MECHANISM FOR TRACING CENTRODES OF TANGENT GENERATORS | LG Ge |
|---|---|---|



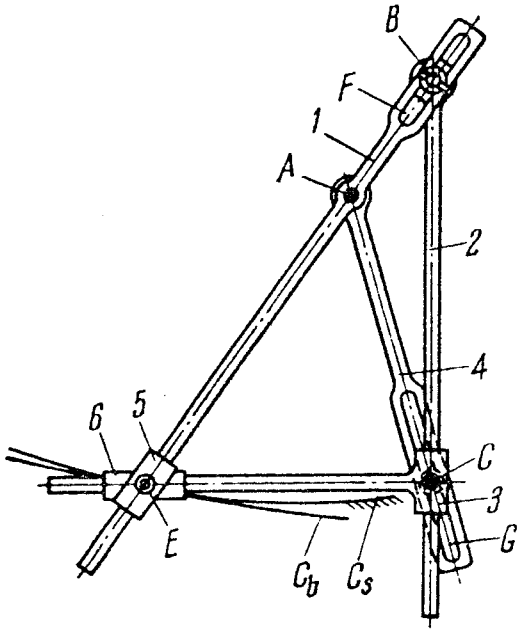

The mechanism is based on a tangent generator consisting of links *1*, *2*, *3* and *4*. Added to this linkage is a double guiding element consisting of two sliders, *5* and *6*, connected together by turning pair *E*. The mechanism is intended for tracing body and space centrodes of links *2* and *4*. The tracing stylus is at the centre of pivot *E*. The mechanism is shown set up for tracing space centrode $C_s$. To trace body centrode $C_b$, slider *2* is secured to the fixed plane and link *4* is released. Centrodes of various shapes can be obtained by adjusting pivot *A* along slot *F* of link *4*.

| 1248 | ARTOBOLEVSKY SLIDING-LINK MECHANISM FOR TRACING CENTRODES OF SLIDING-LINK MECHANISMS | LG Ge |
|---|---|---|



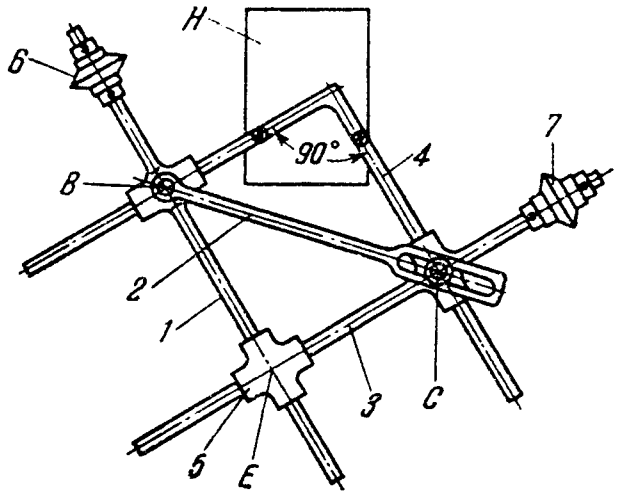

The mechanism is based on sliding-link mechanism *ABC* with sliding link *3* oscillating about fixed axis *C*. Added to the linkage is a double guiding element consisting of two sliders, *5* and *6*, connected together by turning pair *E*. The mechanism is intended for tracing body and space centrodes of links *2* and *4*. The mechanism is shown set up for tracing space centrode $C_s$, i.e. for the case when link *4* is fixed. To trace body centrode $C_b$, slider *2* is secured to the fixed plane and link *4* is released. Centrodes of various shapes can be obtained by varying the lengths of links *1* and *4*. This is accomplished by adjusting pivots *B* and *C* along slots *F* and *G* of links *1* and *4*.

| 1249 | ARTOBOLEVSKY SLIDING-LINK MECHANISM FOR TRACING CENTRODES OF OSCILLATING SLIDER LINKAGES | LG Ge |
|---|---|---|



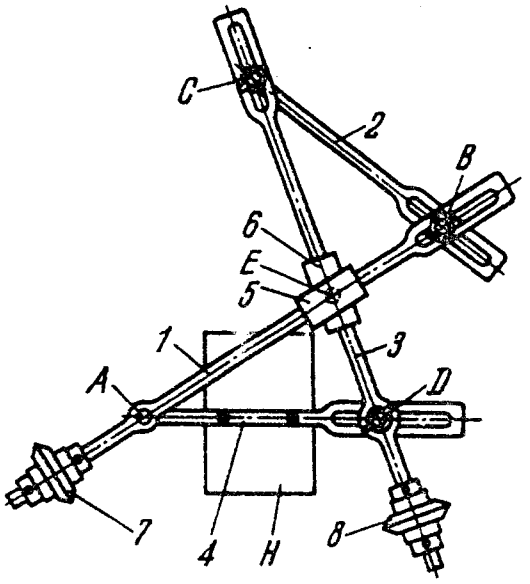

The mechanism is based on sliding-link mechanism *ABC* with slider *3* oscillating about fixed axis *C*. Added to this linkage is a double gu ding element consisting of two sliders, *5* and *6*, connected together by turning pair *E*. The mechanism is intended for tracing body and space centrodes of links *2* and *4*. The tracing stylus is at the centre of pivot *E*. The mechanism is shown set up for tracing space centrode $C_s$. To trace body centrode $C_b$, sliding link *2* is secured to the fixed plane and link *4* is released. Centrodes of various shapes can be obtained by varying the lengths of links *1* and *4*. This is accomplished by adjusting pivots *B* and *C* along slots *F* and *G* of links *1* and *4*.

| 1250 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING ROULETTES OF CIRCLES | LG Ge |
|---|---|---|



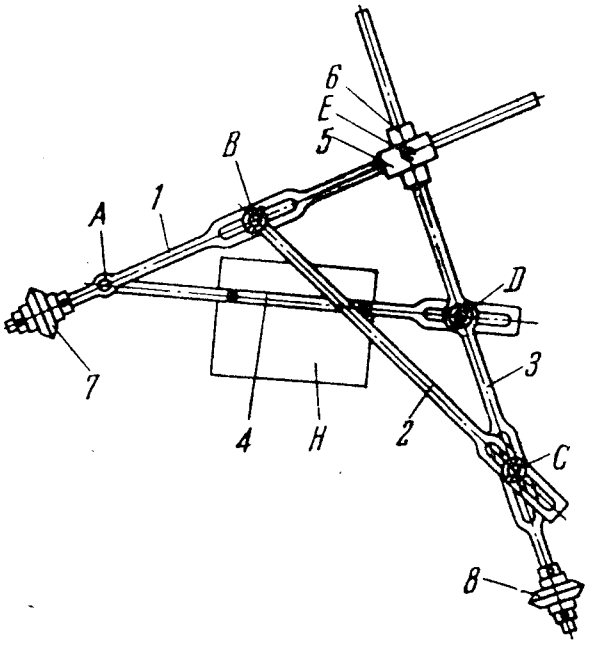

The mechanism is based on a four-bar sliding-link mechanism with two sliders, consisting of links *1*, *2*, *3* and *4*. Added to this linkage is cross-shaped slider *5* having a stylus at its centre *E*. Links *1* and *3* have wheels *6* and *7* with sharp-edged rims. The mechanism is intended for tracing roulettes of circles. For this purpose, stylus *E* is placed on the curve with respect to which the roulette of a circle is to be obtained. Wheels *6* and *7* are set on a plane table. When stylus *E* is moved along the above-mentioned curve so that wheels *6* and *7* roll along the plane table, any point of plane member *H*, attached to link *4*, describes the corresponding roulette of a circle. The mechanism can be set up for various circles by adjusting pivot *C* along the slot in link *2*.

| 1251 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING ROULETTES OF ELLIPSES | LG Ge |
|---|---|---|



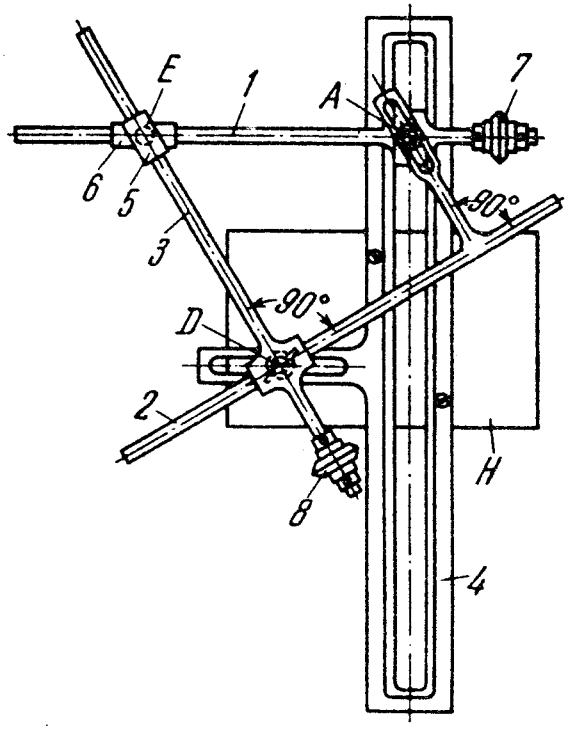

The mechanism is based on crossed-crank linkage *ABCD*. Added to this linkage is a double guiding element consisting of two sliders, *5* and *6*, connected together by turning pair *E*. Links *1* and *3* have wheels *7* and *8* with sharp-edged rims. The mechanism is intended for tracing roulettes of ellipses. For this purpose, a stylus at the centre of pivot *E* is placed on the curve with respect to which the roulette of an ellipse is to be obtained. Wheels *7* and *8* are set on a plane table. When the stylus of pivot *E* is moved along the above-mentioned curve so that wheels *7* and *8* roll along the plane table, any point of plane member *H*, attached to link *4*, describes the corresponding roulette of an ellipse. The mechanism is set up for various ellipses by adjusting pivots *B*, *C* and *D* along the corresponding slots in links *1*, *2*, *3* and *4*.

| 1252 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING ROULETTES OF HYPERBOLAS | LG Ge |
|---|---|---|



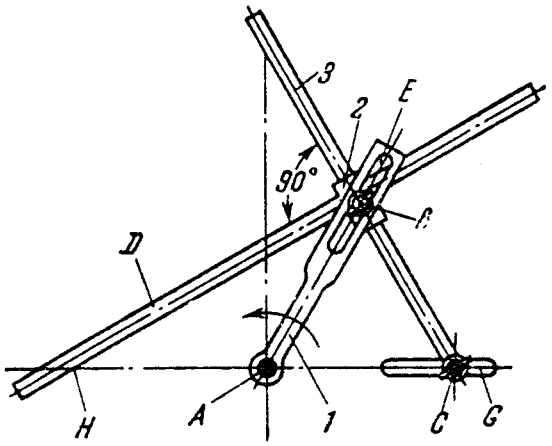

The mechanism is based on crossed-crank linkage *ABCD*. Added to this linkage is a double guiding element consisting of two sliders, *5* and *6*, connected together by turning pair *E*. Links *1* and *3* have wheels *7* and *8* with sharp-edged rims. The mechanism is intended for tracing the roulettes of hyperbolas. For this purpose, a stylus at the centre of pivot *E* is placed on the curve with respect to which the roulette of a hyperbola is to be obtained. Wheels *7* and *8* are set on a plane table. When stylus *E* is moved along the above-mentioned curve so that wheels *7* and *8* roll along the plane table, any point of plane member *H*, attached to link *4*, describes the corresponding roulette of a hyperbola. The mechanism is set up for various hyperbolas by adjusting pivots *B*, *C* and *D* along the corresponding slots in links *1*, *2*, *3* and *4*.

| 1253 | ARTOBOLEVSKY LINK-GEAR MECHANISM FOR TRACING ROULETTES OF PARABOLAS | LG Ge |
|---|---|---|



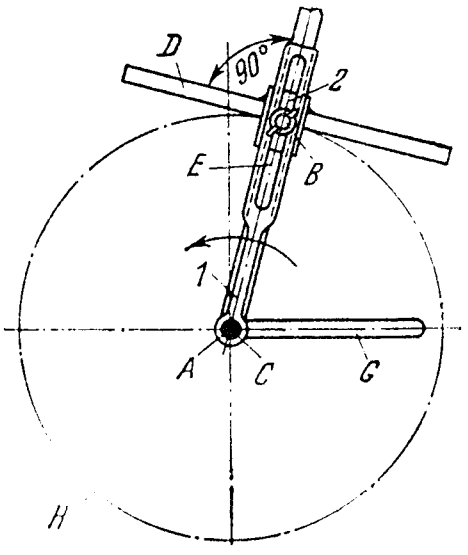

The mechanism is based on a four-bar sliding-link mechanism consisting of links *1*, *2*, *3* and *4*. Added to this linkage is a double guiding element consisting of two sliders, *5* and *6*, connected together by turning pair *E*. Links *1* and *3* have wheels *7* and *8* with sharp-edged rims. The mechanism is intended for tracing the roulettes of parabolas. For this purpose, a stylus at the centre of pivot *E* is placed on the curve with respect to which the roulette of a parabola is to be obtained. Wheels *7* and *8* are set on a plane table. When the stylus of pivot *E* is moved along the above-mentioned curve so that wheels *7* and *8* roll along the plane table, any point of plane member *H*, attached to link *4*, describes the corresponding roulette of a parabola. The mechanism is set up for various parabolas by adjusting pivots *A* and *D* along the corresponding slots in links *2* and *4*.

| 1254 | ARTOBOLEVSKY LINK-GEAR MECHANISM WITH AN OSCILLATING SLIDING LINK FOR ENVELOPING POINTS | LG Ge |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AB} = \overline{AC}$. Crank *1* of length $\overline{AB}$ turns about fixed axis *A*. Sliding link *3* turns about fixed axis *C*. Slider *2*, moving along the axis of sliding link *3*, carries rule *D*. When crank *1* turns about axis *A*, rule *D* envelops point *H*, i.e. the edge of rule *D* always passes through point *H*. At this, slider *2* has Cardan motion. The length $\overline{AB}$ of link *1* is varied by adjusting pivot *B* along slot *E*. The envelopes of various points lying on straight line *AC* can be obtained by adjusting pivots *B* and *C* along slots *E* and *G*.

| 1255 | ARTOBOLEVSKY LINK-GEAR MECHANISM WITH A ROTATING SLIDING LINK FOR ENVELOPING CIRCLES | LG Ge |
|---|---|---|

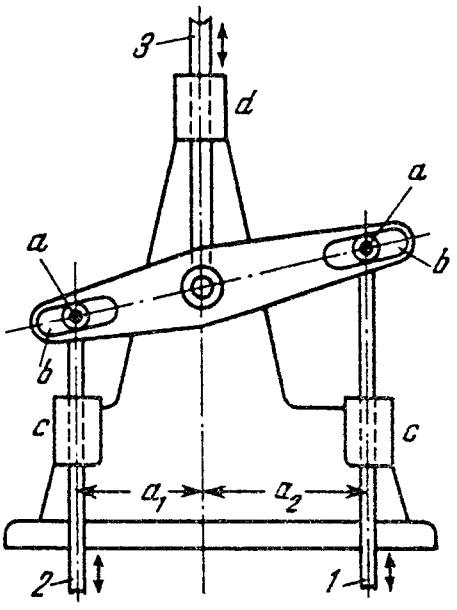



When the centres of fixed pivots *A* and *C* of the illustrated four-bar linkage coincide and crank *1* turns about axis *A*, rule *D*, rigidly secured to slider *2*, envelops circle *H*. Circles of the required radius can be obtained by adjusting pivots *B* and *C* along slots *E* and *G*.

# 7. MECHANISMS FOR MATHEMATICAL OPERATIONS (1256 through 1318)

## 1256 LINK-GEAR ADDING MECHANISM

LG MO



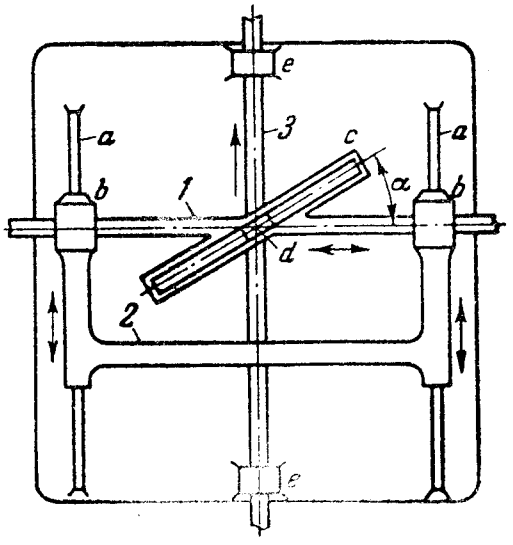

Links *1* and *2* have straight-line motion in guides *c*. At this, link *3* is displaced in guide *d* and rollers *a* slide along slots *b*. The linear displacement *x* of link *3* is expressed by the equation

$$x = \frac{a_1}{a_1 + a_2} x_1 + \frac{a_1}{a_1 + a_2} x_2$$

where $x_1$ and $x_2$ are linear displacements of links *1* and *2*. Thus, the mechanism adds two quantities $x_1$ and $x_2$ which are entered as displacements of links *1* and *2*.

## 1257 LINK-GEAR ADDING MECHANISM

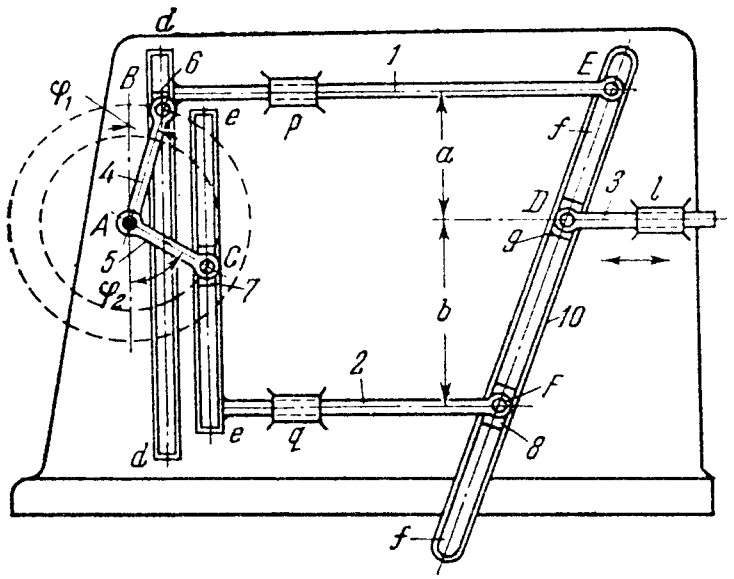
LG MO




Link *2* slides along fixed guides *a*. Link *1* slides in guides *b* of link *2*. Link *3* slides along fixed guides *e*. The axes of guides *a* and *e* are parallel to each other and are perpendicular to the axis of guides *b*. Link *1* has guide *c* whose axis makes the constant angle $\alpha$ with the axis of guides *b*. Rigidly secured to link *3* is slide-block *d* whose axis makes the constant angle $90° - \alpha$ with the axis of guides *e*. The displacement $s_3$ of link *3* is determined from displacements $s_1$ and $s_2$ of links *1* and *2*:

$$s_3 = s_2 + ks_1$$

where $k = \tan \alpha$.



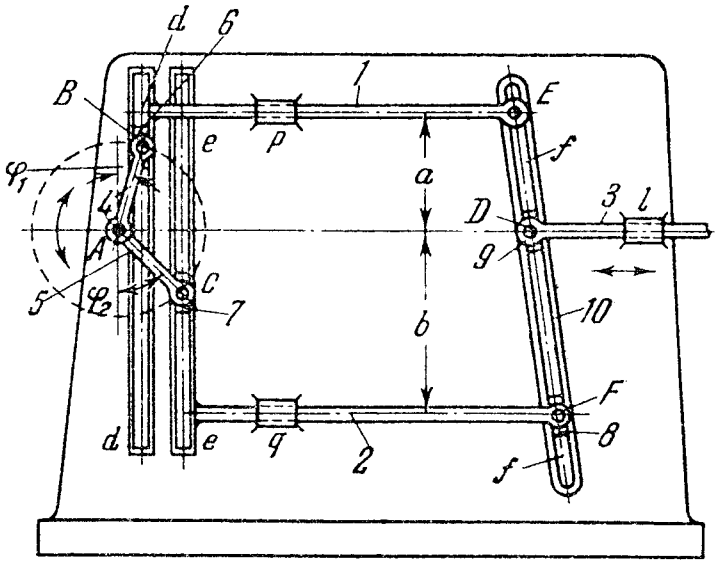

Cranks *4* and *5*, turning about fixed axis *A*, are connected by turning pairs *B* and *C* to sliders *6* and *7* which move in guides *d-d* and *e-e* of links *1* and *2*. Links *1* and *2* slide in fixed guides *p* and *q*. Link *1* is connected by turning pair *E* to slotted link *10*. Link *2* is connected by turning pair *F* to slider *8* which moves along slot *f-f* of link *10*. Link *3* slides in fixed guide *l* and is connected by turning pair *D* to slider *9* which moves along slot *f-f* of link *10*. The displacement $s_3$ of link *3* equals

$$s_3 = m \sin \varphi_1 \pm n \sin \varphi_2$$

where $m = \dfrac{b}{a+b}\,\overline{AB}$

$$n = \frac{a}{a+b}\,\overline{AC}$$

$\varphi_1$ and $\varphi_2$ = angles of rotation of links *4* and *5*.
Thus the linear displacement of link *3* is obtained as the sum or difference of the linear displacements of links *1* and *2*. Lengths $\overline{AB}$ and $\overline{AC}$ of cranks *4* and *5* are not equal.




The lengths of the links comply with the condition: $\overline{AB} = \overline{AC} = k$. Cranks *4* and *5*, turning about fixed axis *A*, are connected by turning pairs *B* and *C* to sliders *6* and *7* which move in guides *d-d* and *e-e* of links *1* and *2*. Links *1* and *2* slide in fixed guides *p* and *q*. Link *1* is connected by turning pair *E* to slotted link *10*. Link *2* is connected by turning pair *F* to slider *8* which moves along slot *f-f* of link *10*. Link *3* slides in fixed guide *l* and is connected by turning pair *D* to slider *9* which moves along slot *f-f* of link *10*. The displacement of link *3* equals

$$s_3 = m \sin \varphi_1 \pm n \sin \varphi_2$$

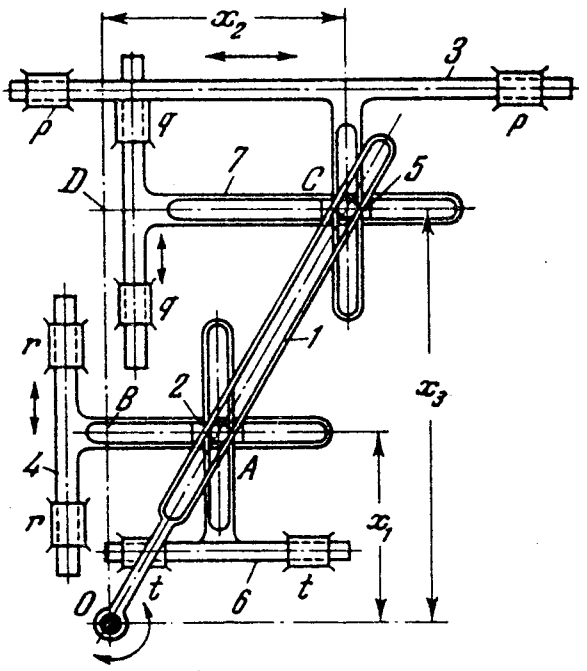
where

$$m = \frac{kb}{a + b} = \text{constant}$$

$$n = \frac{ka}{a + b} = \text{constant}$$

$\varphi_1$ and $\varphi_2$ = angles of rotation of links *4* and *5*.

Thus the linear displacement of link *3* is obtained as the sum or difference of the linear displacements of links *1* and *2*.

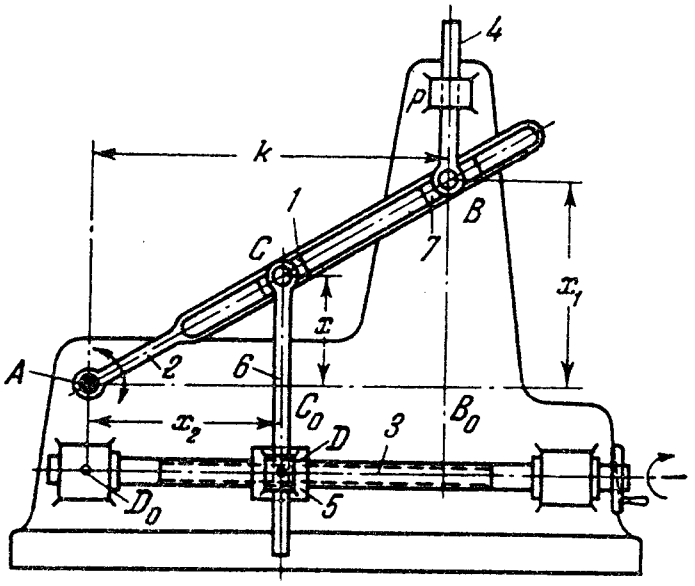



Slotted link *1* turns about fixed axis *O*. Links *3*, *7* and *4* slide in guides *p-p*, *q-q* and *r-r*. Link *6* slides in guides *t-t*. Links *1*, *3* and *6* have slots for pins *A* and *C* of sliders *2* and *5* which move along slots provided in links *4* and *7*. When links *4*, *3* and *7* are set to the distances: $x_1 = \overline{OB}$, $x_2 = \overline{CD}$ and $x_3 = \overline{OD}$, the displacement of link *6* is $s_6 = \overline{BA}$, equal to

$$s_6 = \frac{x_1 \times x_2}{x_3}.$$

Thus the mechanism multiplies three factors: $x_1$, $x_2$ and $1/x_3$.

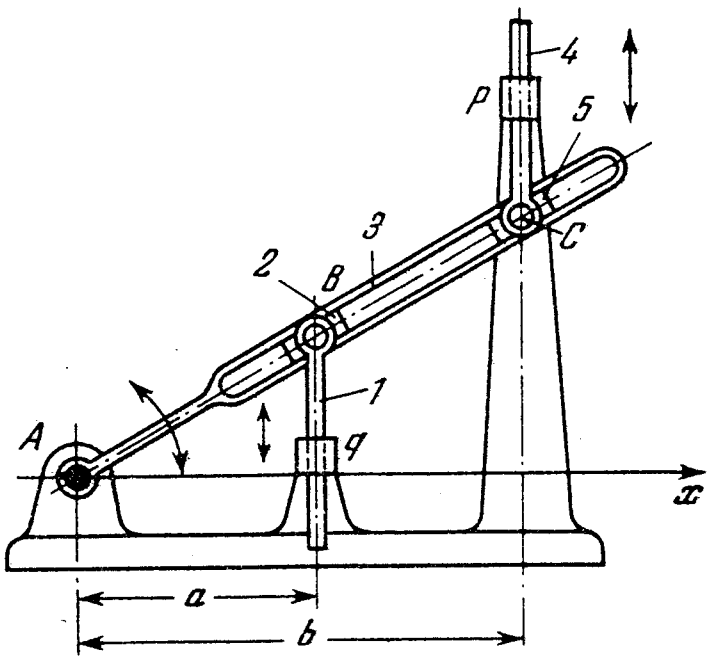
| 1261 | LINK-GEAR MULTIPLIER MECHANISM | LG MO |
|---|---|---|




Sliders *1* and *7* move along the slot of slotted link *2* which turns about fixed axis *A*. Sliders *1* and *7* are connected by turning pairs *C* and *B* to links *6* and *4*. Link *4* slides in fixed guide *p*, and link *6* slides in fixed guide *5* which can be displaced by screw *3* by moving nut *D* along the screw axis. Using the screw device to set point *D* at the distance $x_2 = \overline{DD_0}$ from point $D_0$, and setting point *B* of link *4* at the distance $x_1 = \overline{BB_0}$ from point $B_0$, we obtain the displacement $x = \overline{CC_0}$ of point *C* of link *6*. Then

$$x = \frac{1}{k} x_1 \times x_2$$

where $k$ is a constant dimension of the mechanism. Thus the mechanism multiplies two factors, $x_1$ and $x_2$.

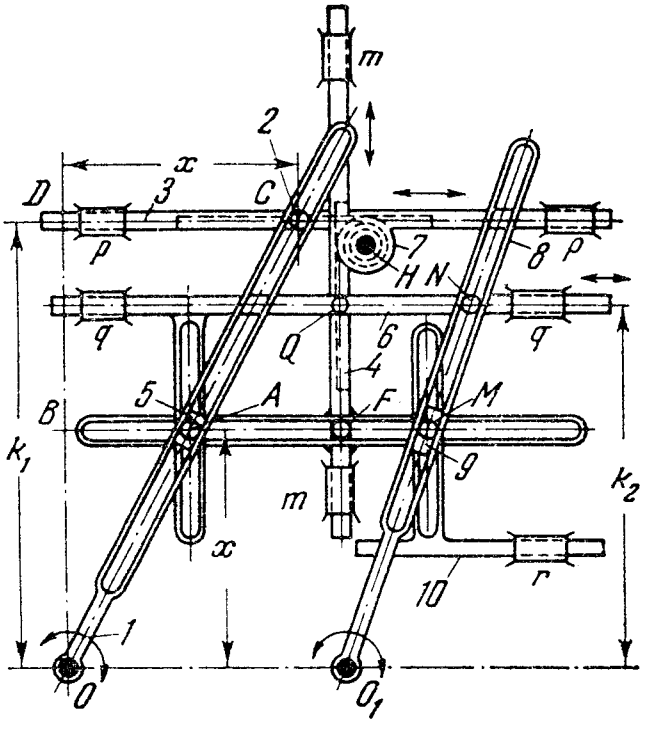



Sliders *2* and *5* move along the slot of slotted link *3* which turns about fixed axis *A*. Sliders *2* and *5* are connected by turning pairs *B* and *C* to links *1* and *4* which slide in fixed guides *q* and *p*. The displacements $s_1$ and $s_4$ of links *1* and *4* are related by the condition

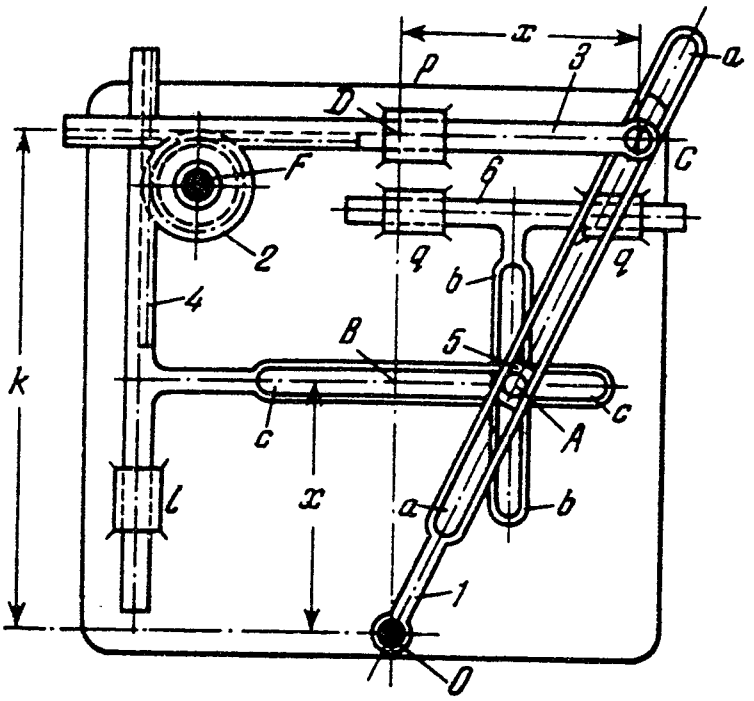
$$s_4 = ks_1$$

where $k = b/a$ is a constant value. Thus the mechanism multiplies a given quantity by the constant quantity $k$.

| 1263 | LINK-GEAR CUBING MECHANISM | LG MO |
|---|---|---|

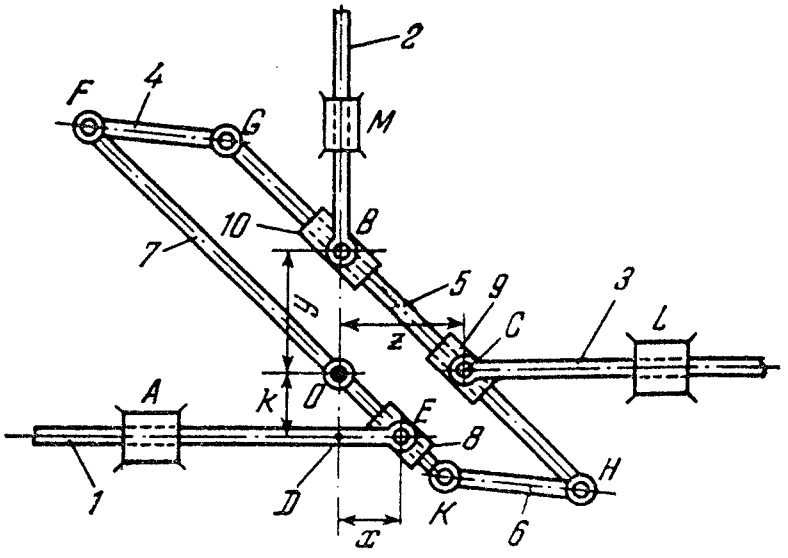



Slotted links *1* and *8* turn about fixed axes $O$ and $O_1$. Sliders *5* and *9* move along the slots of links *1* and *8*, and have pins $A$ and $M$ which simultaneously slide in the slots of links *4*, *6* and *10*. Rigidly secured to link *3* is pin $C$ which slides in the slot of link *1*. Links *3* and *4* carry gear racks which mesh with gear *7*, rotating about fixed axis $H$. Links *3*, *6* and *10* slide in fixed guides $p$, $q$ and $r$ whose axes are parallel to one another. Link *4* slides in fixed guides $m$ whose axis is perpendicular to the axes of guides $p$, $q$ and $r$. When slotted link *1* turns about axis $O$, link *6*, by means of pin $N$, turns slotted link *8* about axis $O_1$. The mechanism is set up so that $\overline{DC} = \overline{BO} = \overline{O_1F} = x$ and $\overline{BA} = \overline{QN}$. Displacement $s_{10} = \overline{FM}$ of link *10* equals $x^3/k_1k_2$, where $k_1$ and $k_2$ are constant dimensions of the mechanism. Thus the mechanism cubes the quantity $x$.




Slotted link *1* turns about fixed axis *O*. Slider *5* with pin *A* moves along slot *a-a* of link *1*. Pin *A* enters slots *b-b* and *c-c* of links *6* and *4*. The axes of slots *b-b* and *c-c* are perpendicular to each other. Link *3* has pin *C* sliding along slot *a-a* of slotted link *1*. Link *3* slides in fixed guide *p*. Link *4* slides in fixed guide *l*. Link *6* slides in fixed guides *q*. The axes of guides *p* and *q* are parallel to each other and perpendicular to guide *l*. Links *3* and *4* carry gear racks which mesh with gear *2* rotating about fixed axis *F*. The gear is set so that distance $\overline{DC} = \overline{OB} = x$. Displacement $s_6 = \overline{AB}$ of link *6* equals $x^2/k$, where $k$ is a constant dimension of the mechanism.

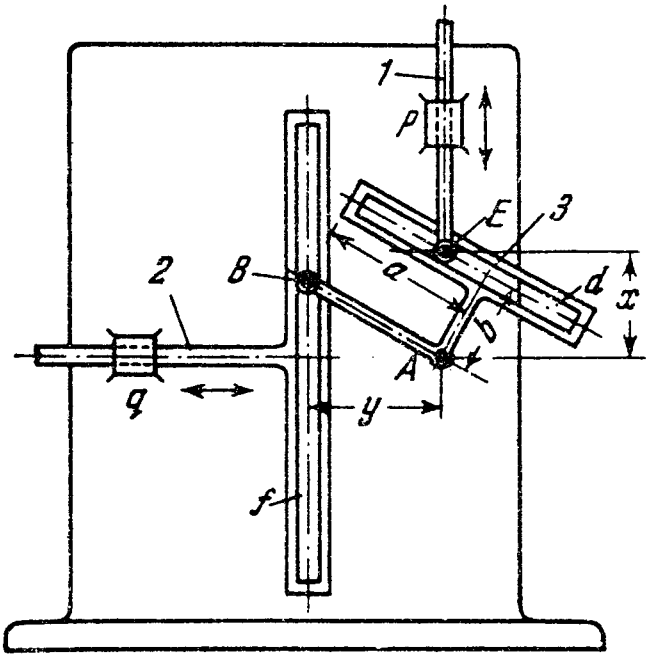
| 1265 | LINK-GEAR MULTIPLIER MECHANISM | LG MO |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{FG} = \overline{KH}$ and $\overline{FK} = \overline{GH}$. Thus links *4*, *5*, *6* and *7* forms a parallel-crank linkage. Links *1*, *2* and *3* slide in fixed guides *A*, *M* and *L*. Sliders *8*, *9* and *10* move along the axes of links *7* and *5*, and are connected by turning pairs *E*, *C* and *B* to links *1*, *3* and *2*. Link *7* turns about fixed axis *O*. The lines of motion of links *2* and *3* are perpendicular to each other and pass through point *O*. The lines of motion of links *1* and *3* are parallel to each other. When link *1* is displaced a distance $x$ and link *2* a distance $y$, driven link *3* is displaced by the amount

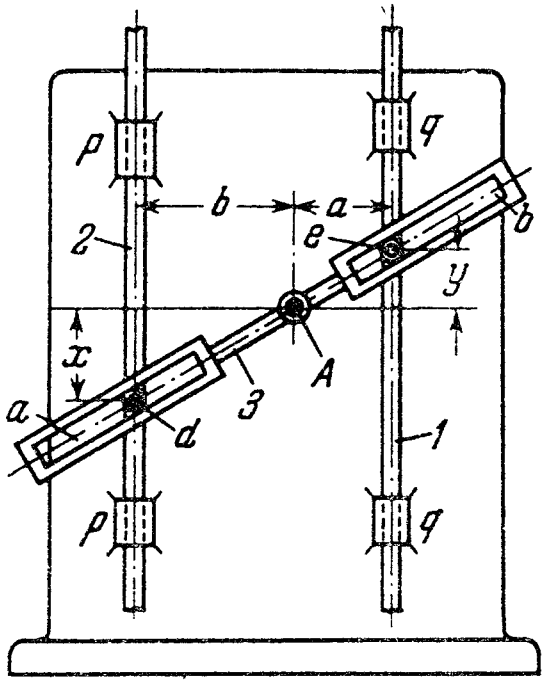
$$z = \frac{xy}{k}$$

where $k$ is a constant dimension of the mechanism. Thus the mechanism multiplies two independent quantities $x$ and $y$.

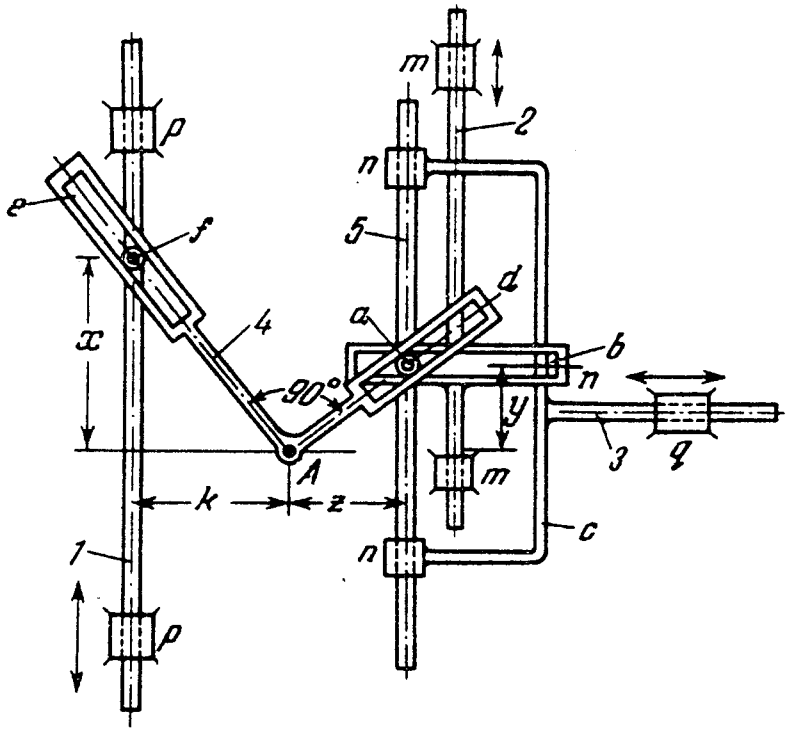



Link *1* slides in fixed guide *p*. Link *2* slides in fixed guide *q* whose axis is perpendicular to that of guide *p*. Link *3* turns about fixed axis *A* and has slot *d* whose axis is parallel to arm *AB* of link *3*. Pin *B* of link *3* slides along slot *f* of link *2*, and pin *E* of link *1* slides along slot *d* of link *3*. The mechanism is intended for the mathematical operation $xy = ab$, where $x$ is the displacement of link *1*, $y$ is the displacement of link *2* and $a$ and $b$ are constant dimensions of the mechanism.

| 1267 | LINK-GEAR MULTIPLIER MECHANISM | LG MO |
|---|---|---|




Links *1* and *2* slide in fixed guides *q* and *p* whose axes are parallel to each other. Link *3* turns about fixed axis *A*. Pins *d* and *e* of links *2* and *1* slide along slots *a* and *b* of link *3*. The mechanism is intended for the mathematical operation $y = kx$, where $y$ is the displacement of link *1*, $x$ is the displacement of link *2* and $k = a/b$ is the ratio of constant dimensions of the mechanism.

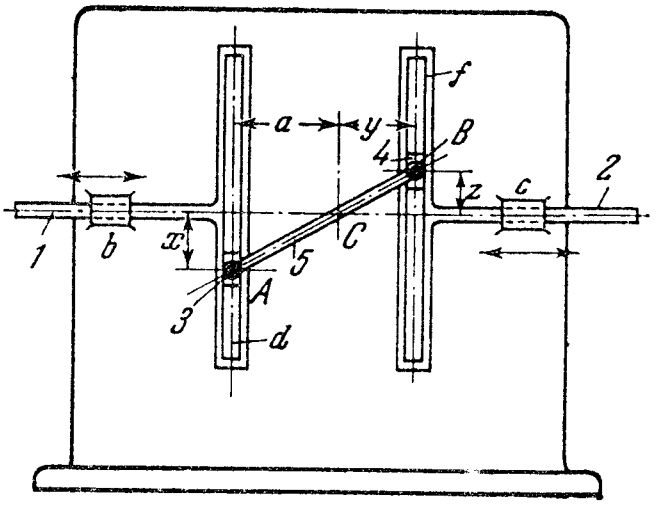



Link *1* slides in fixed guides *p-p*. Link *3* slides in fixed guide *q* whose axis is perpendicular to that of guides *p-p*. Bent lever *4* turns about fixed axis *A*. Link *2* has slot *b* and slides in fixed guides *m-m*. The axis of slot *b* is perpendicular to that of guides *m-m*. Link *3* has fork-shaped portion *c* ending in guides *n-n* in which link *5* slides. Pin *a* of link *5* slides simultaneously along slots *b* and *d* of links *2* and *4*. Pin *f* of link *1* slides along slot *e* of link *4*. The value of one of the factors, *x*, is set up by displacing link *1*; that of the second factor, *y*, by displacing link *2*. Then link *3* is displaced by the amount *z*, equal to

$$z = \frac{xy}{k}$$

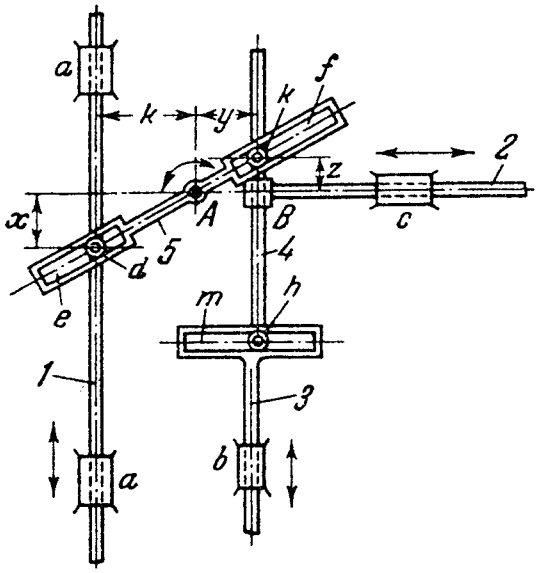
where *k* is a constant dimension of the mechanism.

| 1269 | LINK-GEAR MULTIPLIER MECHANISM | LG MO |
|---|---|---|




Link *1* slides in fixed guide *b* and has slot *d* whose axis is perpendicular to that of guide *b*. Link *2* slides in fixed guide *c* and has slot *f* whose axis is perpendicular to that of guide *c*. Link *5* is connected by turning pairs *A* and *B* to sliders *3* and *4* which move along slots *d* and *f* of links *1* and *2*. The value of one of the factors, $x$, is set up by displacing slider *3* with respect to slotted link *1*. The value of the second factor, $y$, is set up by displacing slot *f* of link *2* the corresponding distance from a certain fixed point *C*. If slot *d* of link *1* is set at the arbitrary distance $a$ from point *C* of link *5*, then slider *4* is displaced the distance $z$ from the axes of guides *b* and *c* equal to

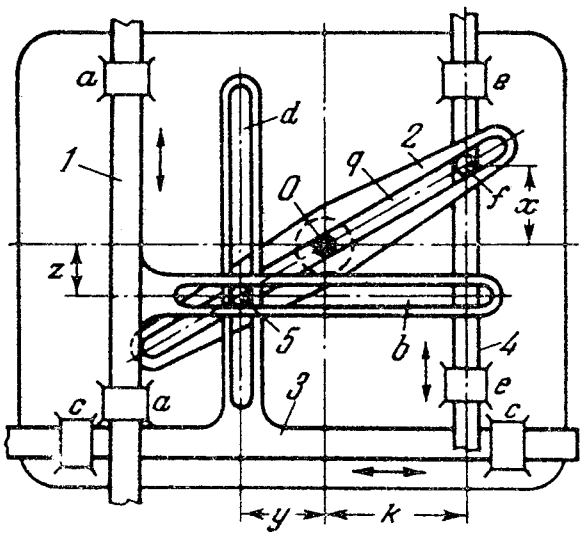
$$z = \frac{xy}{a}.$$




Link *1* slides in fixed guides *a-a* and has pin *d* which slides along slot *e* of link *5*. Link *5* turns about fixed axis *A* and has a second slot *f* which slides along pin *k* of link *4*. Link *4* is connected by sliding pair *B* to link *2* and has pin *h* which slides along slot *m* of link *3*. Link *2* slides in fixed guide *c*, and link *3* in fixed guide *b*. The value of one of the factors, *x*, is set up by displacing link *1*; that of the second factor, *y*, by displacing link *2*. At this, link *4* and slot *m* of link *3* are displaced vertically by the amount

$$z = \frac{1}{k} xy$$

where *k* is a constant dimension of the mechanism, being the distance from point *A* to the axis of guides *a-a*.



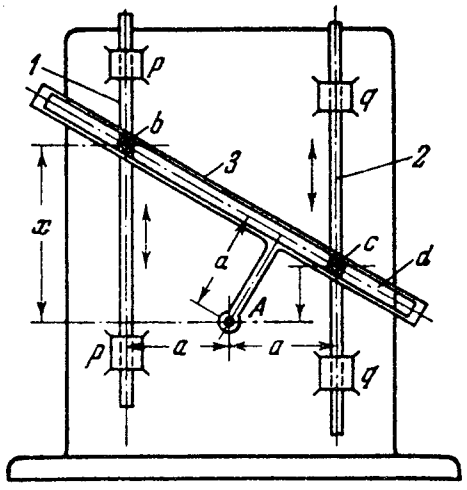

Link *1* slides in fixed guides *a-a* and has slot *b* whose axis is perpendicular to that of guides *a-a*. Link *3* slides in fixed guides *c-c* and has slot *d* whose axis is perpendicular to that of guides *c-c*. The axes of slots *b* and *d* are perpendicular to each other. Link *4* slides in fixed guides *e-e* whose axis is parallel to that of guides *a-a*. Link *4* has pin *f* sliding along slot *q* of link *2* which turns about fixed axis *O*. Pin *5* slides simultaneously along slots *b*, *d* and *q* of links *1*, *3* and *2*. When pin *f* is displaced by the amount *x* and link *3* by the amount *y*, the displacement *z* of link *1* is

$$z = \frac{1}{k} xy$$

where *k* is a constant dimension of the mechanism, being the distance from point *O* to the axis of guides *e-e*.

## 1272 LINK-GEAR MULTIPLIER MECHANISM

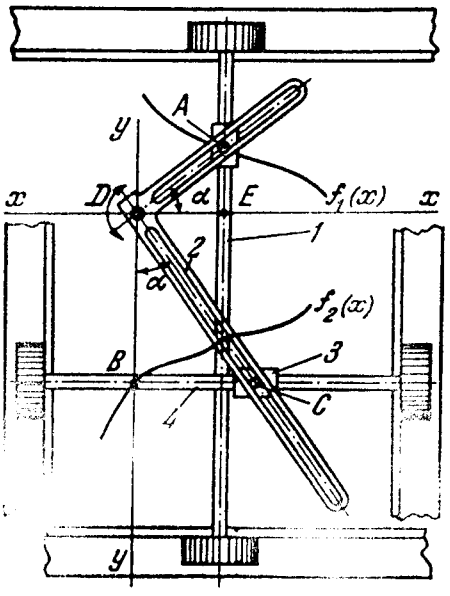
LG
MO




Links *1* and *2* slide in fixed guides *p-p* and *q-q* whose axes are parallel to each other. Link *3* turns about fixed axis *A* and has slot *d*. Pins *b* and *c* of links *1* and *2* slide along slot *d*. The mechanism is intended for the mathematical operation $xy = a^2$, where $x$ is the displacement of link *1*, $y$ is the displacement of link *2* and $a$ is a constant dimension of the mechanism.

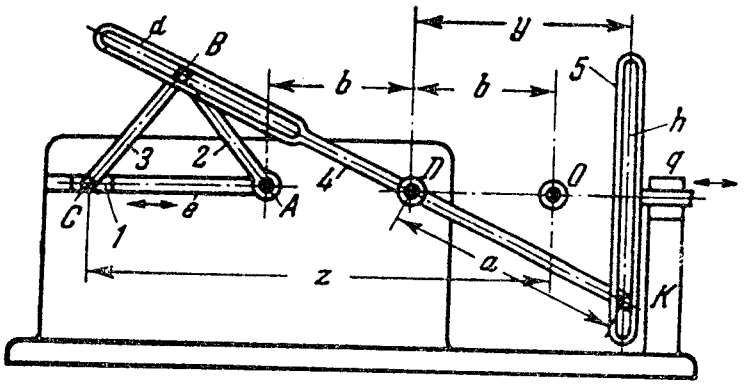
## 1273 KRYLOV LINK-GEAR MULTIPLIER MECHANISM

LG
MO




When stylus *A* is moved along curve $f_1(x)$, carriage *1* moves along axis *x-x*, and slotted link *2* turns about fixed axis *D*. At this, slider *3* moves along guide *4* which is displaced along axis *y-y* so that $\overline{DB}$ is always equal to $f_2(x)$ and the distance $\overline{BC} = \overline{DB} \tan \alpha = f_2(x) \times f_1(x)$. Distance $\overline{DE}$ is taken equal to the unit of the scale in which functions $f_2(x)$ and $f_1(x)$ are plotted.

| 1274 | LINK-GEAR MECHANISM FOR EXTRACTING SQUARE ROOTS | LG MO |
|---|---|---|



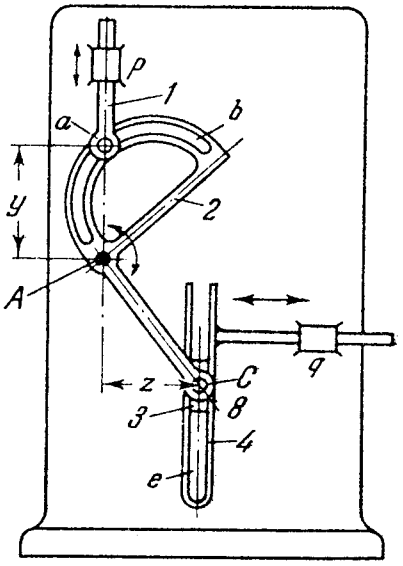

The lengths of the links comply with the conditions: $\overline{AB} = \overline{BC} = \overline{AD} = \overline{DO} = b$ and $\overline{DK} = a$. Link *2* turns about fixed axis *A* and is connected by turning pair *B* to link *3*. Slot *d* of link *4* slides along a pin at point *B*. Slider *1* is connected by turning pair *C* to link *3* and moves along fixed guide *e*. Slotted link *4* turns about fixed axis *D* and its pin *K* slides in slot *h* of link *5* which slides in fixed guide *q*. The mechanism is intended for the mathematical operation

$$y = \frac{a}{2b^2}\sqrt{z}$$

where $z$ = distance of point *C* of slider *1* from fixed point *O*
$y$ = distance from axis of slot *h* of link *5* to point *D*
$a$ and $b$ = constant dimensions of the mechanism.

## 1275 LINK-GEAR MECHANISM FOR RAISING TO A POWER

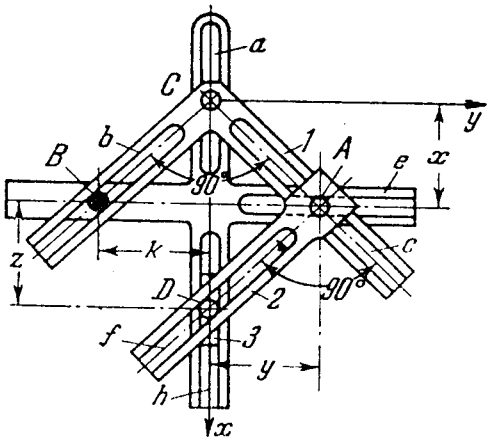
LG MO



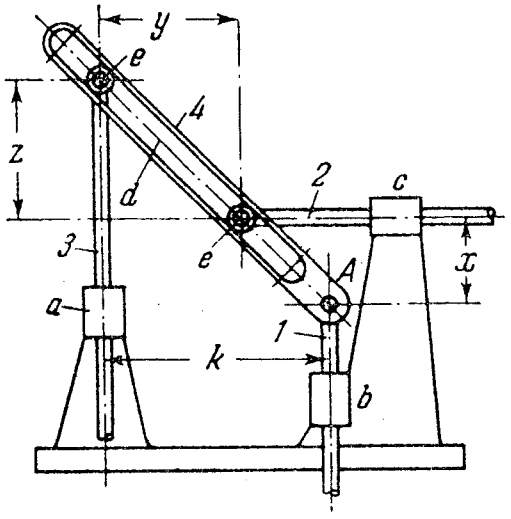

Link *1* slides in fixed guide *p* and ends in roller *a* which slides along profiled slot *b* in link *2*. Link *2* turns about fixed axis *A* and is connected by turning pair *C* to slider *3*. Slider *3* moves along slot *e* of link *4* which slides in fixed guide *q*. Quantity *y*, that is to be raised to a power, is set by link *1* whose pin *a* turns link *2* about axis *A*. The motion of link *2* is transmitted to link *4* whose displacement equals $z = ky^n$, where *k* is a constant dimension of the mechanism. Each value of power *n* corresponds to a definite profile of curvilinear slot *b*.

## 1276 BURSTEIN SLOTTED-LINK CUBING MECHANISM

LG MO




Bent link *1* has slot *b* which slides along fixed pin *B*. Pin *C* of link *1* slides along fixed slot *a*. Slider *2* moves along the axis of slot *c* of link *1* and has pin *A* which simultaneously slides along slot *c* and fixed slot *e*. Slot *f* of link *2* slides along pin *D* of slider *3* which moves along fixed guides *h*. When pin *C* of link *1* slides along guides *a*, link *1* displaces sliders *2* and *3*. Here $y = x^2/k$ and $z = x^3/k^2$, where *k* is a constant dimension of the mechanism.

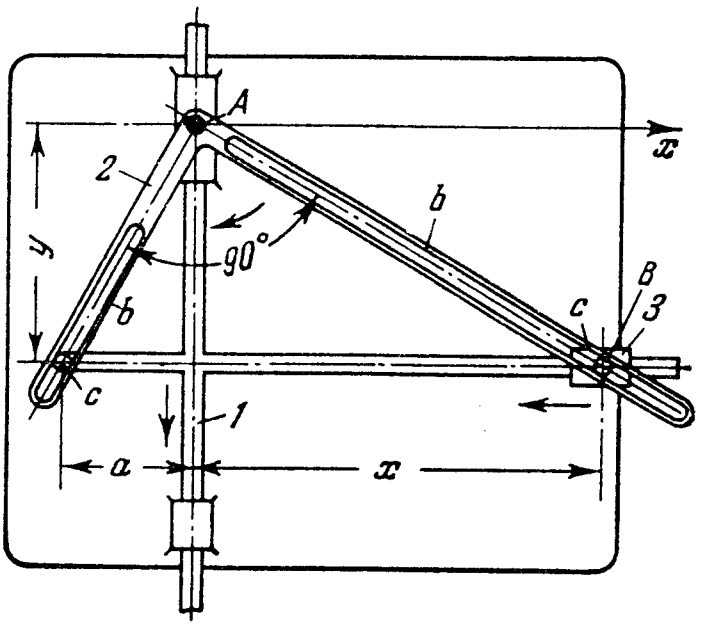



Links *1* and *3* slide in parallel guides *b* and *a* with the distance *k* between their axes. Link *2* slides in guide *c* whose axis is perpendicular to those of guides *a* and *b*. Link *1* is connected by turning pair *A* to link *4* along whose slot *d* pins *e* of links *2* and *3* slide. The displacement of link *3* by the amount *z* is the result of the displacements of links *1* and *2* by the amounts *x* and *y*. Thus

$$z = \frac{xy}{k-y}$$

where *k* is a constant dimension of the mechanism. Thus the mechanism multiplies two quantities *x* and *y* which are entered as the displacements of links *1* and *2*.

| 1278 | LINK-GEAR SQUARING MECHANISM | LG MO |
|---|---|---|



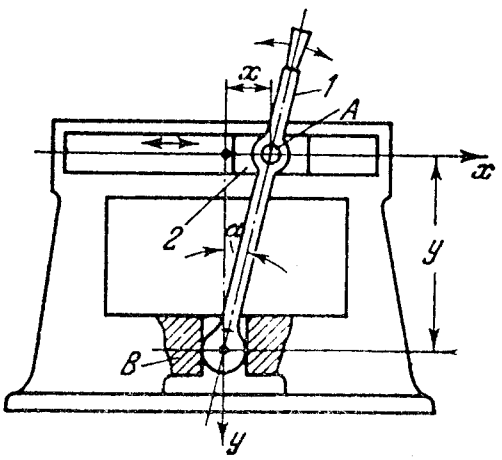

Right-angled bent link *2* has two slots *b* whose axes are perpendicular to each other. Sliding along these slots are pins *c* of a diameter equal to the width of the slots. Displacement *x* of slider *3* equals the square of the displacement of link *1*, i.e.

$$x = \frac{1}{a} y^2.$$

The mechanism can be used as a parabolograph because point *B*, the centre of pin *c* of slider *3*, traces a parabola.

## 1279 THREE-LINK SINE GENERATOR

LG
MO




The oscillating motion of lever *1* is converted into reciprocation of slider *2*. The spherical end of lever *1* slides along vertical guides of the upright. Displacements $x$ and $y$ of points $A$ and $B$ are related by the equation

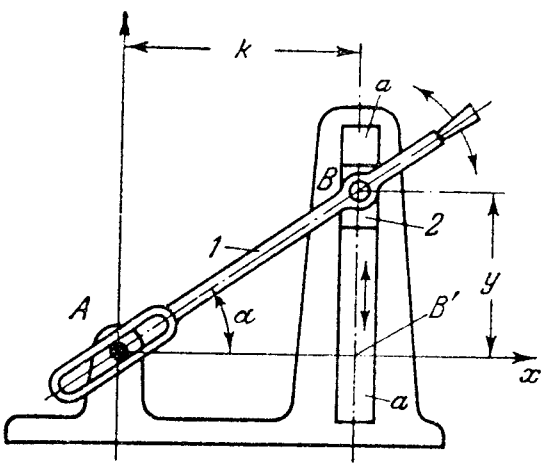
$$y = \sqrt{\overline{AB}^2 - x^2}.$$

The angle $\alpha$ of rotation of lever *1* equals

$$\alpha = \arcsin \frac{x}{\overline{AB}}.$$

## 1280 THREE-LINK SECANT GENERATOR

LG
MO



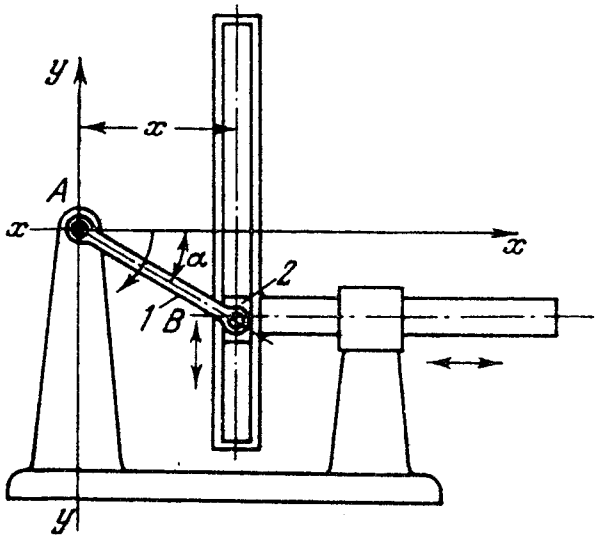

The slot of link *1* slides along fixed pin $A$ secured to the upright. Link *1* is connected by turning pair $B$ to slider *2* which reciprocates in fixed straight guides $a$-$a$ of the upright. Variable distance $\overline{AB}$ equals

$$\overline{AB} = k \sec \alpha.$$

Displacement $y$ of point $B$ of slider *2* from its extreme lower position $B'$ equals $y = k \tan \alpha$, where $\alpha$ is the angle between axis $AB$ of slotted link *1* and axis $Ax$.

## 1281 SLOTTED-LINK SINE GENERATOR

LG MO




The mechanism is intended for generating sine and cosine functions. When crank *1* is turned through angle $\alpha$, slide *2* moves the distance $x$ equal to

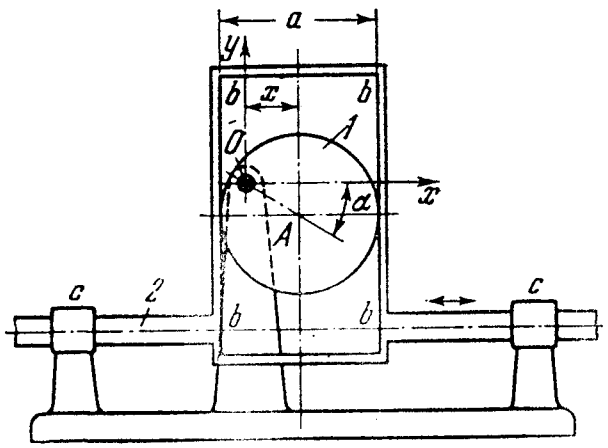
$$x = a \cos \alpha =$$

$$= a \sin \left( \frac{\pi}{2} - \alpha \right)$$

where $a = \overline{AB}$.

## 1282 THREE-LINK ECCENTRIC-TYPE SLOTTED-LINK SINE GENERATOR

LG MO



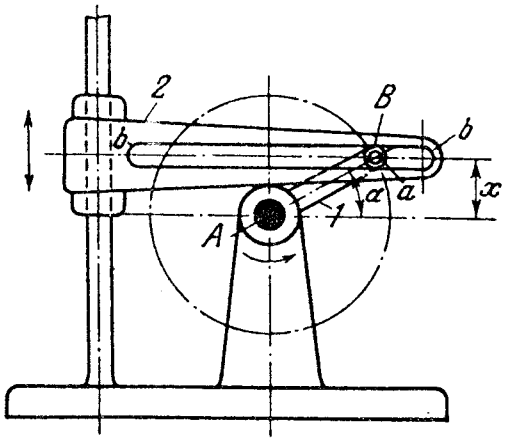

Eccentric cam *1* turns about fixed axis *O* and acts on vertical sides *b-b* of the rectangular frame of link *2*, sliding the link in fixed guides *c-c*. Displacement $x$ of link *2* equals

$$x = \overline{OA} \cos \alpha =$$

$$= \overline{OA} \sin \left( \frac{\pi}{2} - \alpha \right).$$

Width $a$ of the frame is constant and equal to the diameter of cam *1*.

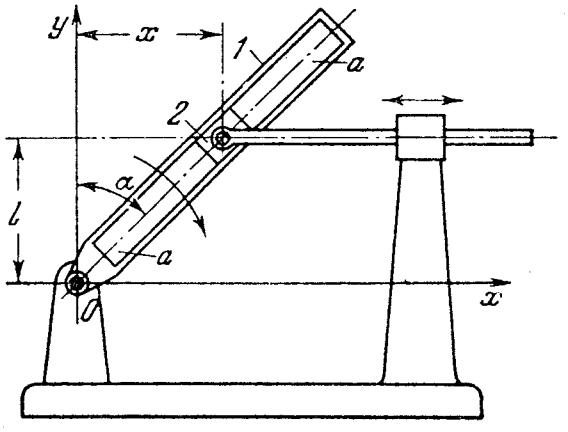
| 1283 | THREE-LINK SLOTTED-LINK SINE GENERATOR | LG MO |
|---|---|---|




Crank *1* turns about fixed axis *A* and ends in round roller *a* which slides in slot *b-b* of link *2*, the diameter of the roller being equal to the width of the slot. The mechanism is intended for generating sine and cosine functions. Linear displacement *x* of link *2* is proportional to the sine of angle $\alpha$ of revolution of crank *1*, i.e.

$$x = \overline{AB} \sin \alpha = \overline{AB} \cos \left( \frac{\pi}{2} - \alpha \right).$$

| 1284 | SLOTTED-LINK TANGENT GENERATOR | LG MO |
|---|---|---|

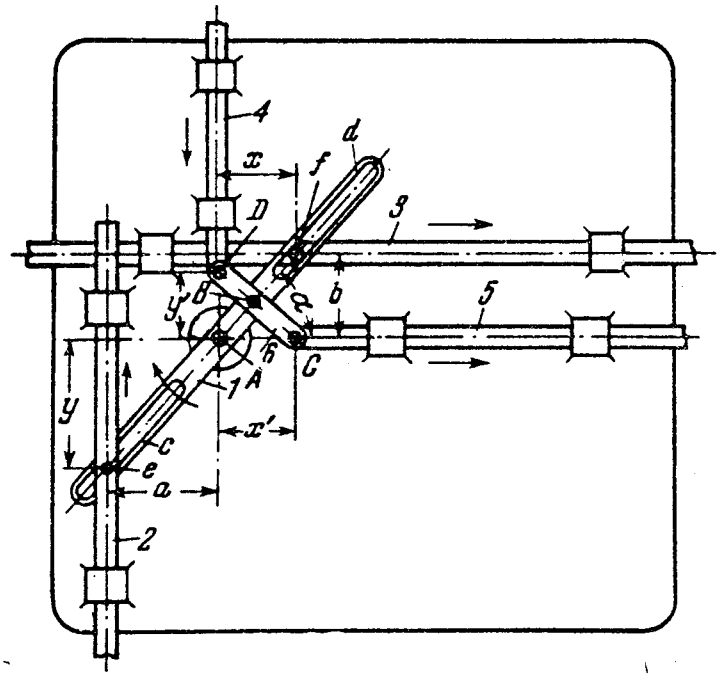



The mechanism is intended for generating tangent and cotangent functions. When slotted link *1* is turned through angle $\alpha$, slider *2* is moved to a position at the distance *x* which equals

$$x = l \tan \alpha = l \frac{1}{\cot \alpha}.$$

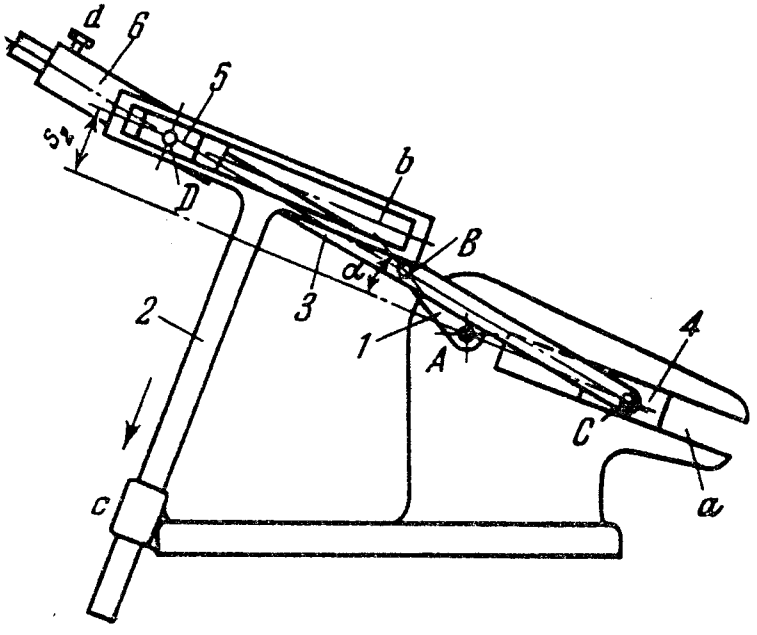
The mechanism can generate functions of the tangent and cotangent within definite limits of angle $\alpha$ which are restricted by the length of slot *a-a* of link *1*.

| 1285 | LINK-GEAR TRIGONOMETRIC FUNCTION GENERATOR | LG MO |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AB} = \overline{BC} = \overline{BD}$. Crank *1* has two slots, *c* and *d*, along which pins *e* and *f* of links *2* and *3* slide. Connecting rod *6* is connected by turning pair *B* to crank *1* and by turning pairs *D* and *C* to links *4* and *5*. Links *2*, *3*, *4* and *5* slide in fixed guides which are perpendicular to one another. When crank *1* turns about fixed axis *A*, displacement $y$ of link *2* is proportional to the tangent of angle $\alpha$ of revolution of crank *1*, i.e. $y = a \tan \alpha$. Displacement $x$ of link *3* is proportional to the cotangent of angle $\alpha$ since $x = b \cot \alpha$. Displacement $y'$ of link *4* is proportional to the sine of angle $\alpha$, i.e. $y' = 2r \sin \alpha$, where $2r = \overline{DC}$. Displacement $x'$ of link *5* is proportional to the cosine of angle $\alpha$, i.e. $x' = 2r \cos \alpha$, where $r = \overline{AB}$.

| 1286 | LINK-GEAR ADJUSTABLE-PARAMETER SINE GENERATOR | LG MO |
|---|---|---|

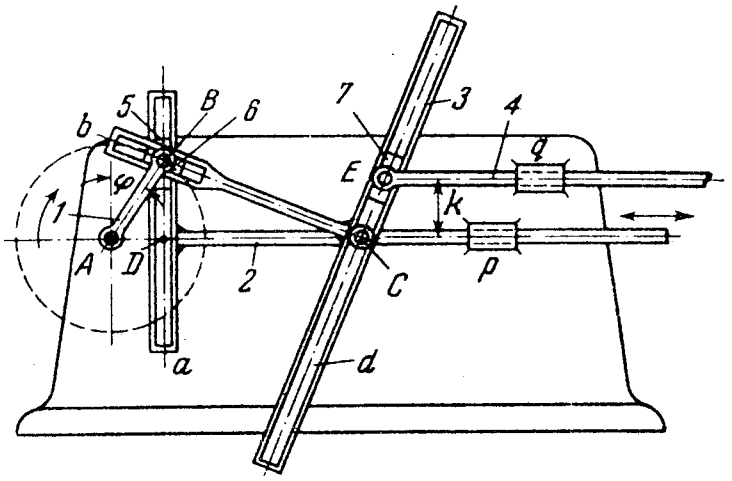



Slider *6* can be clamped by means of screw *d* at any point along the axis of connecting rod *3* of slider-crank linkage *ABC*. Link *2* slides in fixed guide *c* whose axis is perpendicular to axis *a* of motion of slider *4* and axis *b* of motion of slider *5*. When crank *1* turns about fixed axis *A*, displacement $s_2$ of slotted link *2* is proportional to the sine of angle $\alpha$ of rotation of crank *1* with respect to axis *a*. Thus

$$s_2 = \frac{\overline{DC} \times \overline{AB}}{\overline{BC}} = k \sin \alpha.$$

Different values of factor $k$ can be obtained by varying the distance $\overline{DC}$.

| 1287 | LINK-GEAR SINE-PLUS-COSINE GENERATOR | LG MO |
|---|---|---|



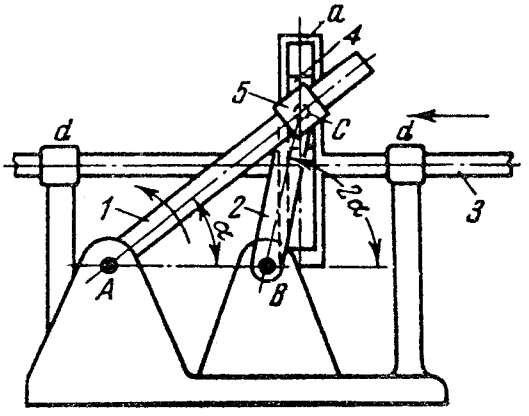

The lengths of the links comply with the conditions: $\overline{AB} = r$ and $\overline{CD} = f$. Crank *1* turns about fixed axis *A* and is connected by turning pair *B* to slider *5* which moves along slot *a* of link *2*. Link *2* slides in fixed guide *p* and is connected by turning pair *C* to link *3* which has the form of a T-shaped lever with two slots *b* and *d* perpendicular to each other. Slider *6*, moving along slot *b*, is connected by turning pair *B* to slider *5*. Slider *7*, moving along slot *d*, is connected by turning pair *E* to link *4* which slides in fixed guide *q*. The displacement of link *4* in guide *q* equals

$$s_4 = r\left(1 - \sin\varphi + \frac{k}{f}\cos\varphi\right)$$

i.e. the linear displacement of link *4* is obtained as the result of the linear displacement of link *2* and the rotation of slotted link *3*.

## 1288 LINK-GEAR GENERATOR FOR COSINES OF TWICE AN ANGLE

LG MO

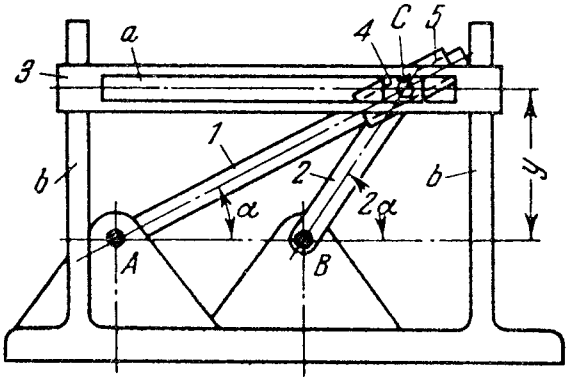



The lengths of the links comply with the condition: $\overline{AB} = \overline{BC}$. Link *1*, turning about fixed axis *A*, is connected by a sliding pair to slider *5*. Slider *5* is connected by turning pair *C* to slider *4* which moves along guides *a* of link *3*. Link *3* slides in fixed guides *d-d*. When link *1* turns through angle $\alpha$, crank *2* turns through angle $2\alpha$, and slotted link *3* is displaced the amount *x* which is proportional to the cosine of twice the angle $\alpha$, so that

$$x = \overline{BC} \cos 2\alpha.$$

## 1289 LINK-GEAR GENERATOR FOR SINES OF TWICE AN ANGLE

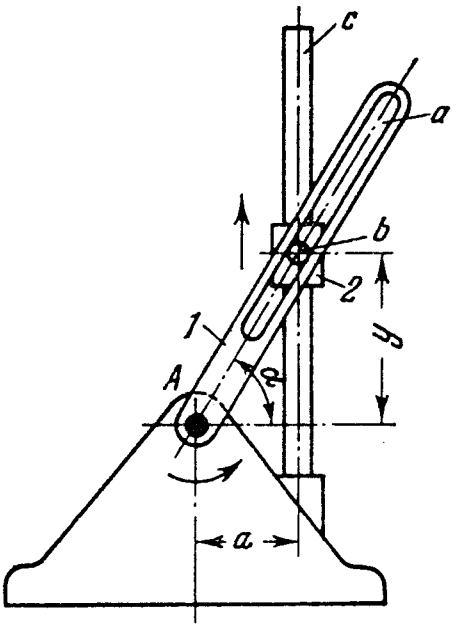
LG MO




The lengths of the links comply with the condition: $\overline{AB} = \overline{BC}$. Link *1*, turning about fixed axis *A*, is connected by a sliding pair to slider *5*. Slider *5* is connected by turning pair *C* to slider *4* which moves along guides *a* of link *3*. Link *3* slides vertically along uprights *b*. When link *1* turns through angle $\alpha$, crank *2* turns through angle $2\alpha$, and slotted link *3* is displaced vertically by the amount *y* which is proportional to the sine of twice the angle $\alpha$ so that

$$y = \overline{BC} \sin 2\alpha.$$

| 1290 | THREE-BAR LINK-GEAR TANGENT GENERATOR | LG MO |
|---|---|---|



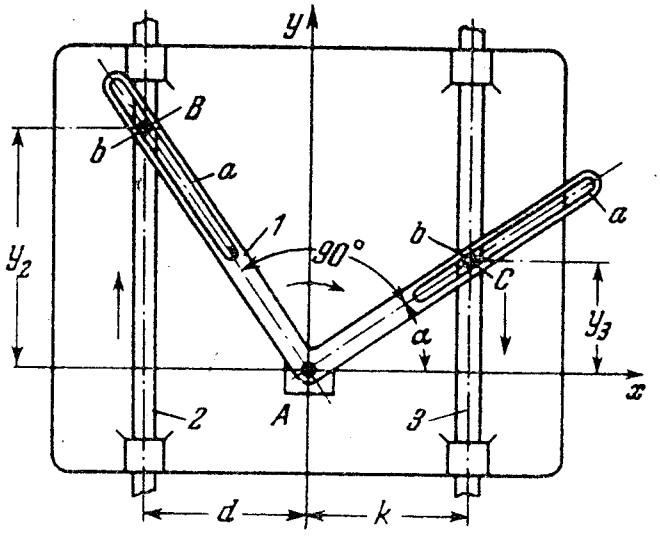

Link *1* turns about fixed axis *A* and has slot *a* along which pin *b* of slider *2* moves. Slider *2* moves along column *c* of the upright. Displacement *y* of slider *2* in the vertical direction is proportional to the tangent of the angle $\alpha$ of rotation of slotted link *1*:

$$y = a \tan \alpha.$$

1291

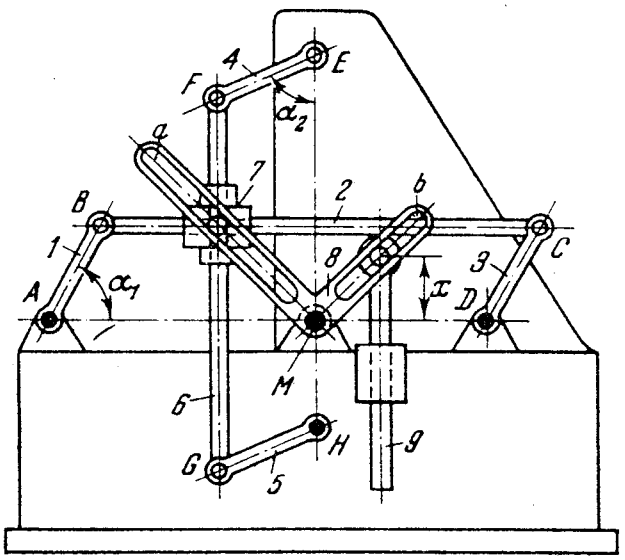
# LINK-GEAR TANGENT AND COTANGENT GENERATOR

LG MO




Right-angled slotted link *1* turns about fixed axis *A* and has two slots *a* whose axes are perpendicular to each other. Pins *b* of links *2* and *3* slide along slots *a* of link *1*. The diameter of the pins equals the width of the slots. When slotted link *1* turns about axis *A*, links *2* and *3* are displaced in opposite directions. Displacement $y_3$ of link *3* equals $y_3 = k \tan \alpha$, and displacement $y_2$ of link *2* equals $y_2 = d \cot \alpha$, where $\alpha$ is the angle of rotation of link *1*. Thus the mechanism simultaneously generates two functions: $\tan \alpha$ and $\cot \alpha$.

| 1292 | LINK-GEAR MECHANISM FOR GENERATING SINE RATIOS OF TWO ANGLES | LG MO |
|---|---|---|

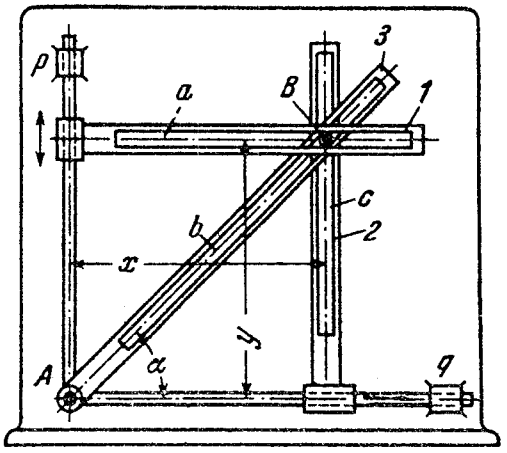



The lengths of the links comply with the conditions: $\overline{AB} = \overline{CD} = \overline{EF} = \overline{HG}$ and $\overline{BC} = \overline{AD} = \overline{FG} = \overline{EH}$. Cross-shaped slider *7* has guides perpendicular to each other and moves along the axes of links *2* and *6*. Bent slotted link *8* turns about fixed axis *M* and has two slots *a* and *b* whose axes are perpendicular to each other. Linear displacement *x* of rod *9* is proportional to the ratio of the sine of angle $\alpha_1$ to the sine of angle $\alpha_2$. This displacement is obtained as the result of the angular displacements of links *1* and *4*, since the mechanism satisfies the condition

$$x = \overline{AB}\,\frac{\sin\alpha_1}{\sin\alpha_2}\,.$$

## 1293 LINK-GEAR TANGENT GENERATOR

LG
MO



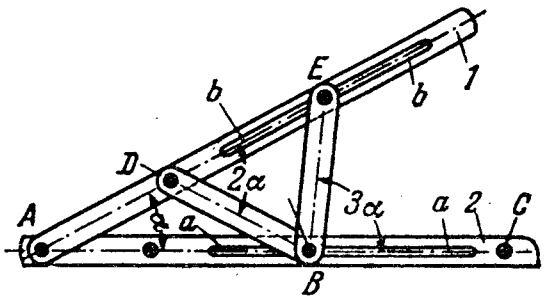

Slotted links *1* and *2* slide in fixed guides *p* and *q* whose axes are perpendicular to each other. Slotted link *3* turns about fixed axis *A*. Pin *B* slides simultaneously along slots *a*, *b* and *c* of links *1*, *3* and *2*. The mechanism generates the ratio

$$\tan \alpha = \frac{y}{x}$$

where $\alpha$ is the angle of rotation of slotted link *3*, $y$ is the vertical displacement of link *1* and $x$ is the horizontal displacement of link *2*.

## 1294 FOUR-BAR SLOTTED-LINK ANGLE MULTIPLIER MECHANISM

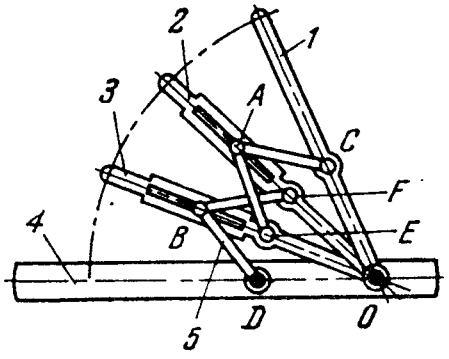
LG
MO




The lengths of the links comply with the condition: $\overline{AD} = \overline{DB} = \overline{BE}$. Links *1* and *2* are connected together by turning pair *A*. Pin *B* slides along slot *a-a* of link *2*; pin *E* along slot *b-b* of link *1*. For an arbitrary position of link *1* with respect to link *2*, angle $DAB = \alpha$, angle $EDB = 2\alpha$ and angle $EBC = 3\alpha$.

## 1295 SLOTTED-LINK TRISECTOR MECHANISM

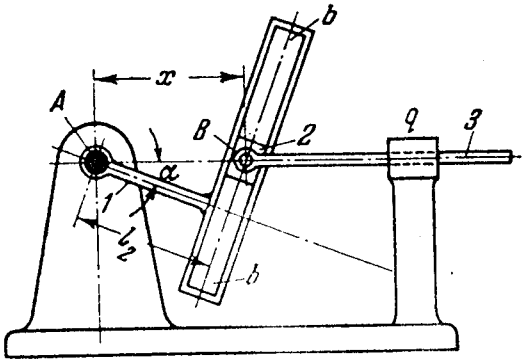
LG
MO




The lengths of the links comply witht he conditions: $\overline{OD} = \overline{OE} = \overline{OF} = \overline{OC}$ and $\overline{AC} = \overline{AE} = \overline{BF} = \overline{BD}$. Links *1*, *2* and *3* turn about fixed axis *O*. Link *5* turns about fixed axis *D*. Pins *A* and *B* slide along slots of links *2* and *3*. For an arbitrary position of link *1* with respect to link *4*, links *2* and *3* divide the angle between fixed link *4* and link *1* into three equal parts.

## 1296 SLOTTED-LINK SECANT GENERATOR

LG
MO

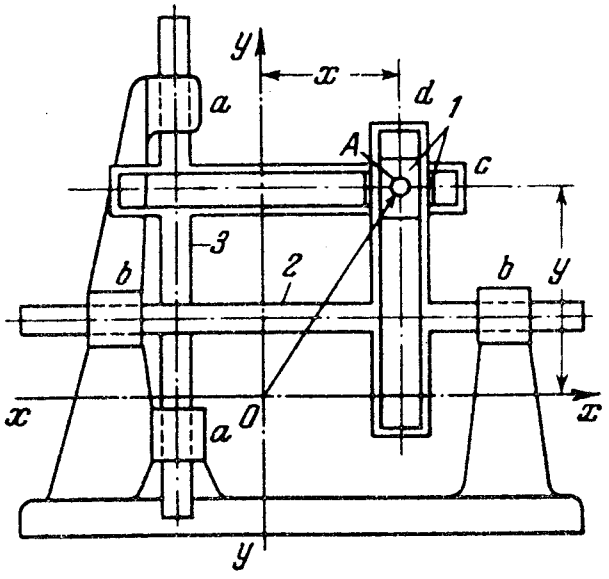



Link *1*, turning about fixed axis *A*, has guides *b-b* along which slider *2* moves. Slider *2* is connected by turning pair *B* to link *3* which slides in fixed guide *q*. When link *1* turns through angle $\alpha$, point *B* of slider *2* is at a position in which the distance $x$ is equal to

$$x = \frac{l_2}{\cos \alpha}$$

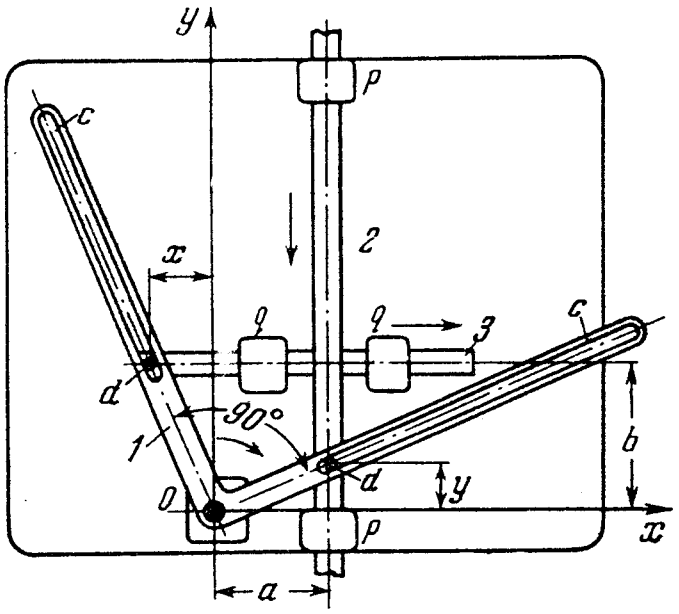
where $l_2$ is the distance from point *A* to the axis of guide *b-b*. Thus $x$ is proportional to the secant of angle $\alpha$. The generator operates only within a limited range of values of angle $\alpha$.

| 1297 | LINK-GEAR RECTANGULAR COORDINATE MECHANISM | LG MO |
|---|---|---|




Link *3* slides in fixed guides *a-a*. Link *2* slides in fixed guides *b-b*. Cross-shaped slider *1* moves simultaneously along two guides, *c* and *d*, of links *3* and *2*. The axes of guides *c* and *d* are perpendicular to each other. If point *O*, the tail of vector $\overline{OA}$, is given together with coordinates *x* and *y* of its head, the mechanism determines the magnitude of vector $\overline{OA}$ as the geometric sum of the displacements *x* and *y* of links *2* and *3* in guides *b-b* and *a-a*, i.e. the quantity $\overline{OA} = \sqrt{x^2 + y^2}$.

| 1298 | LINK-GEAR MECHANISM FOR MUTUALLY PERPENDICULAR LINK MOTION | LG MO |
|---|---|---|

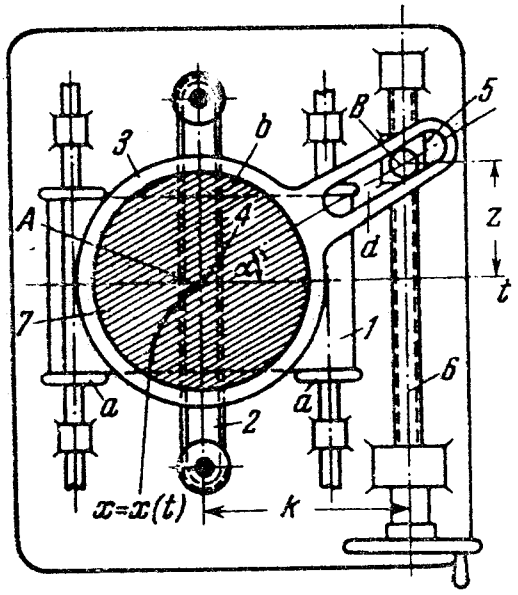



Bent link *1* turns about fixed axis *O* and has two slots *c* whose axes are perpendicular to each other. Pins *d* of links *2* and *3* slide along slots *c* and are of a diameter equal to the width of the slots. Links *2* and *3* slide in fixed guides *p-p* and *q-q* whose axes are perpendicular to each other. When link *1* turns about axis *O*, links *2* and *3* are displaced in mutually perpendicular directions. Displacements *x* and *y* of links *3* and *2* are related by the condition

$$\frac{x}{y} = \frac{b}{a} = \text{const.}$$

# 1299 SLOTTED-LINK MECHANISM FOR GRAPHICAL DIFFERENTIATION

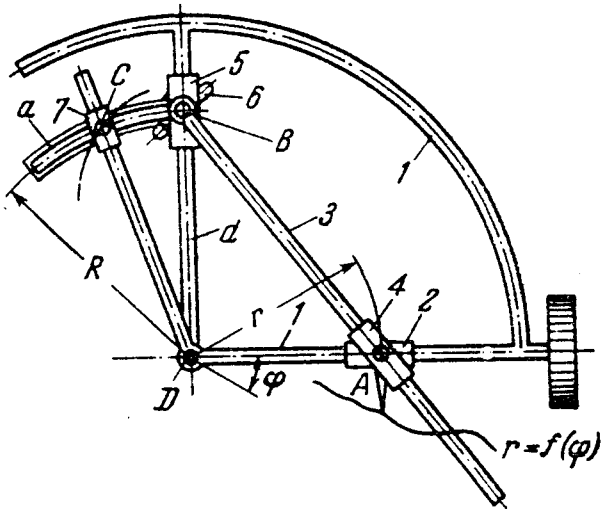
LG MO




This instrument is intended for the graphic differentiation of various curves of the type $x = x(t)$, i.e. to obtain the value of the function $\dot{x} = \dot{x}(t)$. Curve $x = x(t)$ is plotted on paper tape *1* which is wound from one reel *a* to the other at a rate proportional to the quantity $t$. Pencil *4* is secured to flexible cord *2* and is displaced vertically at a rate proportional to quantity $x$. Thus, in simultaneous motion of paper tape *1* and pencil *4*, the continuous curve $x = x(t)$ is traced on the tape. Link *3*, turning about fixed axis *A*, has slot *d* which slides along pin *B* of nut *5*. Nut *5* is connected by a screw pair to screw *6*. Transparent disk *7*, secured rigidly to link *3*, has on its face engraved lines *b* parallel to the axis of slot *d*. To find the derivative of function $x = x(t)$, disk *7* and link *3* are swivelled by turning screw *6* until one of the lines *b* is tangent to the curve $x = x(t)$ at the point at which the derivative $\dot{x} = \dot{x}(t)$ is to be found. The quantity proportional to this derivative is

$$\tan \alpha = \frac{1}{\kappa} z$$

where $\alpha$ = angle between line $AB$ and axis $At$
$k$ = constant dimension of the mechanism, being the distance from point $A$ to the axis of screw *6*.

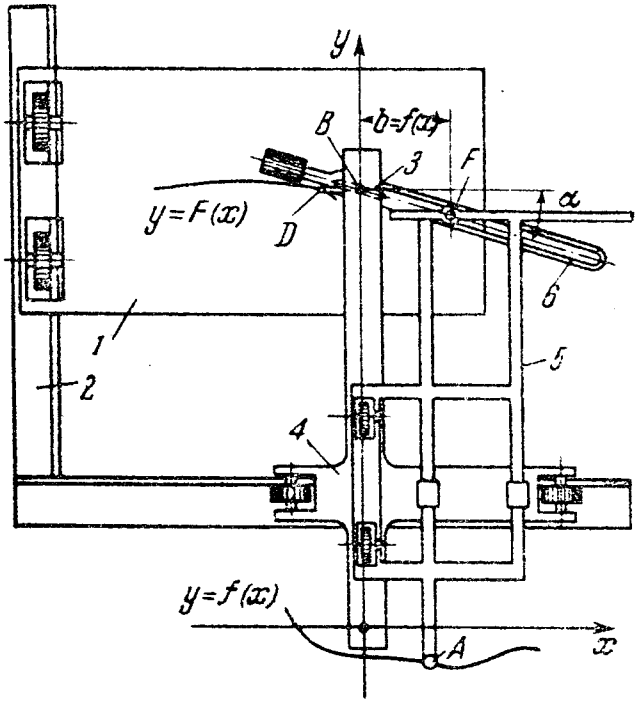



When stylus $A$ follows curve $r = f(\varphi)$, link *1* turns about fixed axis $D$. Slider *2* moves along guiding link *1*. Sliding link *3* is connected by turning pair $B$ to slider *5* and by a sliding pair to slider *4*. Sliders *2* and *4* are connected together by turning pair $A$. Slider *5* moves along guide $d$. Circular guides $a$ are rigidly secured to slider *5* and they move together. Stylus $C$ on slider *7* describes the integral curve with the equation

$$R = \int r\, d\varphi.$$

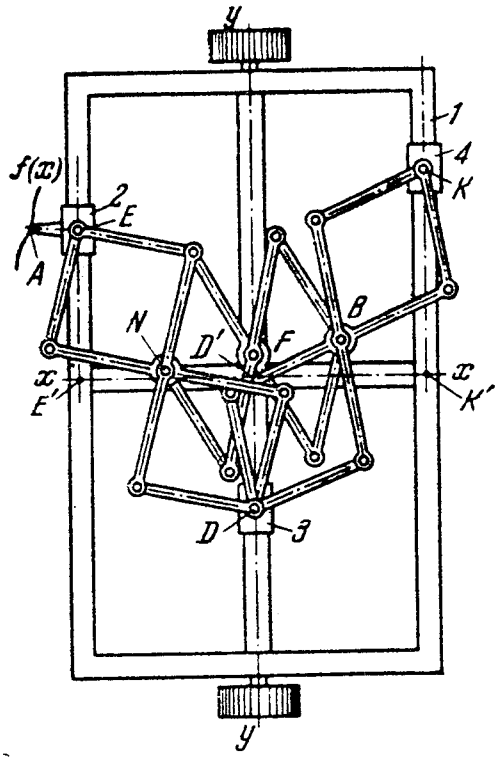
Sharp-edged wheel *6*, perpendicular to sliding link *3*, restricts axial motion of link *3*.

| 1301 | LINK-GEAR INTEGRAPH MECHANISM | LG MO |
|---|---|---|

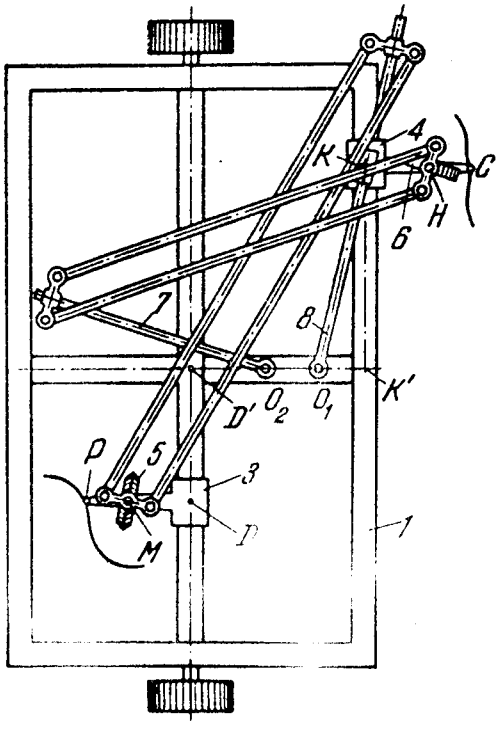



When stylus $A$ follows the given curve $y = f(x)$, stylus $D$ traces the integral curve $y = F(x)$ on carriage *1*. Carriage *1* moves along guide *2* by means of sharp-edged wheel *3* which swivels about axis $B$ of carriage *4*. Carriage *4* travels in the direction of the $x$-axis. Travelling along carriage *4* in the direction of the $y$-axis is carriage *5* whose pin $F$ slides along the slot of link *6* which turns about axis $B$. The distance between points $F$ and $B$ equals $b = f(x)$. Since the axis of slotted link *6* is always parallel to the plane of wheel *3*, then the angle

$$\alpha = \arctan \frac{y}{b}.$$




(a)




(в)

When stylus $A$ follows curve $y = f(x)$, carriage *1* (Fig. *a*) moves along axis $x$-$x$, and sliders *2*, *3* and *4* move along the guiding members of carriage *1* in the direction of the $y$-axis. Sliders *2*, *3* and *4* are connected together by lazy tongs linkages which operate as adding mechanisms. Besides, the middle points $N$ and $B$ of these linkages are connected together by a third lazy tongs linkage for which the following relationship holds true

$$\overline{FD'} = \frac{1}{4}(\overline{EE'} + 2\overline{DD'} + \overline{KK'}).$$

At points $M$ and $H$ (Fig. *b*), sliders *3* and *4* are connected by turning pairs to sharp-edged wheels *5* and *6* whose axes move, by means of parallel-crank linkages, perpendicular to guiding levers *7* and *8*. Stylus $P$ describes a curve whose ordinates are determined by the equation

$$\overline{DD'} = \int \frac{\overline{KK'}}{\overline{O_1K'}}\,dx = \frac{b}{K_1}\int \frac{dz}{dx}\,dx = \frac{b}{K_1}z + K$$

where $K_1 = \overline{O_1K'}$ is a constant. Stylus $C$ describes a curve with the ordinates

$$\overline{KK'} = \int \frac{\overline{FD'}}{\overline{O_2D'}}\,dx.$$

Taking the integration constant to be $K = 0$, and since $\overline{O_2D'} = K_2$ is a constant, we have

$$\overline{FD'} = \frac{1}{4}\left[f(x) + 2\frac{b}{K_1}z + b\frac{dz}{dx}\right]$$

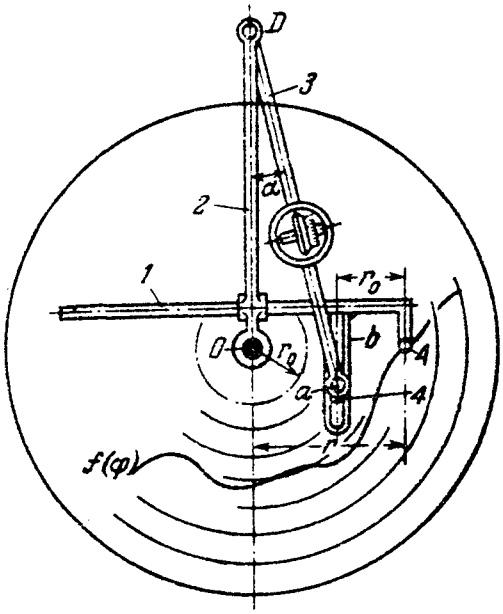
$$\overline{KK'} = \int \frac{\overline{FD'}}{K_2}\,dx = \int \frac{1}{4K_2}\left[f(x) + 2\frac{b}{K_1}z + b\frac{dz}{dx}\right]dx = b\frac{dz}{dx}$$

$$4bK_2\frac{d^2z}{dx^2} - b\frac{dz}{dx} - 2\frac{b}{K_1}z - f(x) = 0.$$

If at $x = 0$ styluses $P$ and $C$ are set to the given initial values $bz/K_1$ and $b\,(dz/dx)$, then when stylus $A$ is moved along curve $f(x)$, styluses $P$ and $C$ trace in a definite scale the integral curve with the equation $az'' + bz' + cz + d = 0$ and the curve of its first derivative.

## 1303 LINK-GEAR RADIAL INTEGRIMETER MECHANISM

LG
MO



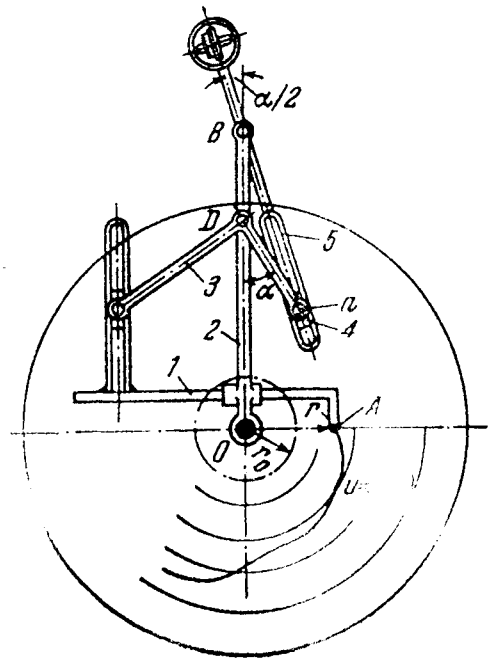

When stylus $A$ is moved along curve $f(\varphi)$, link *1* slides in the guide of link *2* which turns about pole *O*. At this, link *3* turns about pivot *D* and its pin *a*, connected by a turning pair to slider *4*, moves along slot *b* of link *1*. The number of revolutions of the measuring wheel is proportional to the integral

$$u = c \int (r - r_0)\, d\varphi$$

where $c$ = proportionality factor
$\varphi$ = angle of rotation of link *1*.

## 1304 LINK-GEAR RADIAL INTEGRIMETER MECHANISM

LG
MO

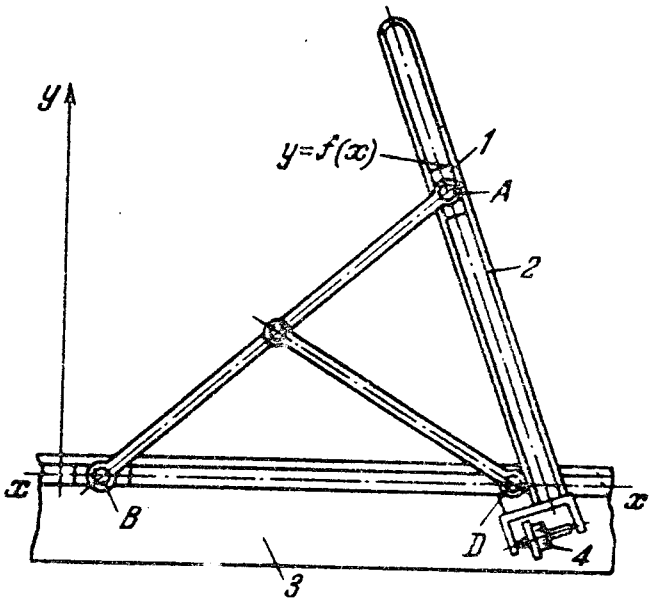



When stylus $A$ is moved along curve $f(\varphi)$, link *1* slides in the guide of link *2* which turns about pole *O*. At this, bent link *3* turns about pivot *D* and its pin *a*, connected by a turning pair to slider *4*, moves along the slot in link *5*, turning link *5* about pivot *B*. The number of revolutions of the measuring wheel is proportional to the integral

$$u = c \int \sqrt{r - r_0}\, d\varphi$$

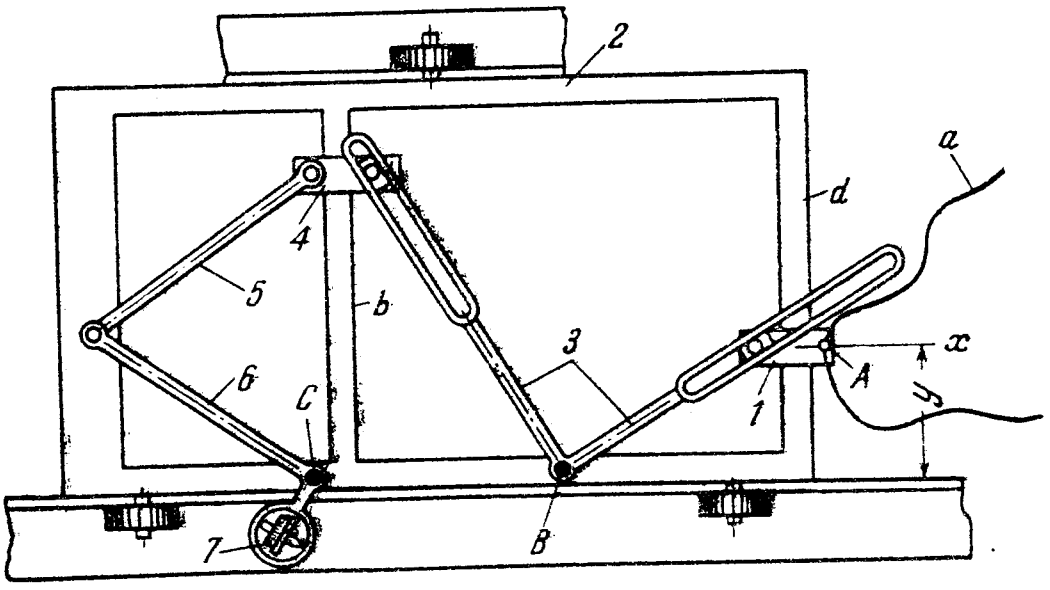
where $c$ = proportionality factor
$\varphi$ = angle of rotation of link *1*.

| 1305 | LINK-GEAR INTEGRIMETER MECHANISM | LG MO |
|---|---|---|




When stylus $A$ is moved along curve $y = f(x)$, slider *1* moves along the slot of link *2*. Pins $D$ and $B$ slide along slot $x$-$x$ of guiding link *3*. The angle of rotation of measuring wheel *4* is proportional to the integral $\int \frac{dx}{y}$.

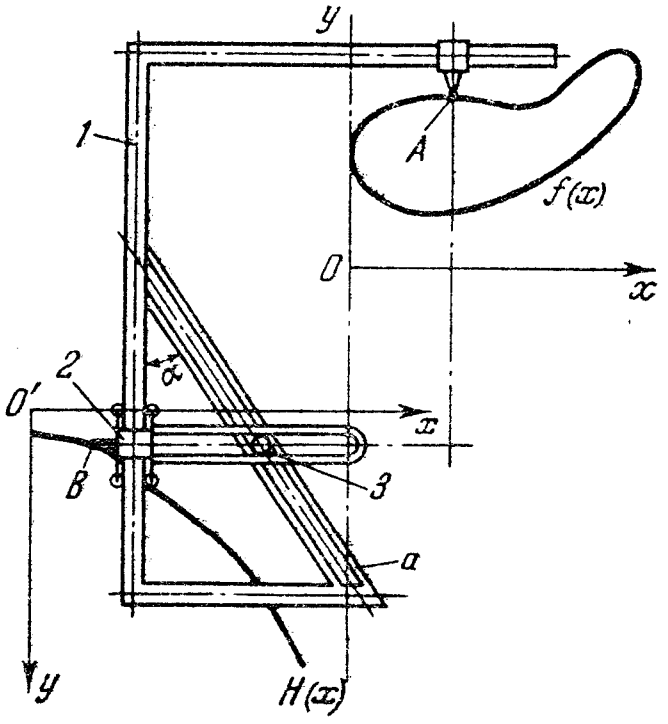
| 1306 | LINK-GEAR INTEGRATOR MECHANISM | LG MO |
|---|---|---|




When stylus $A$ is moved along curve $a$, slider *1* moves along guide $d$ of carriage *2*. At this, bent slotted link *3*, turning about axis $B$, fixed on the carriage, moves slider *4* along guide $b$. Slider *4* is connected by a turning pair to link *5* which, in turn, is connected by a turning pair to link *6*. Measuring wheel *7* is mounted at the end of link *6*. The number of revolutions of the wheel is proportional to the sought-for integral $\int \frac{1}{y} dx$.

Axes of pivots $B$ and $C$ are fixed on the carriage.

| 1307 | LINK-GEAR INTEGRATOR MECHANISM | LG MO |
|---|---|---|

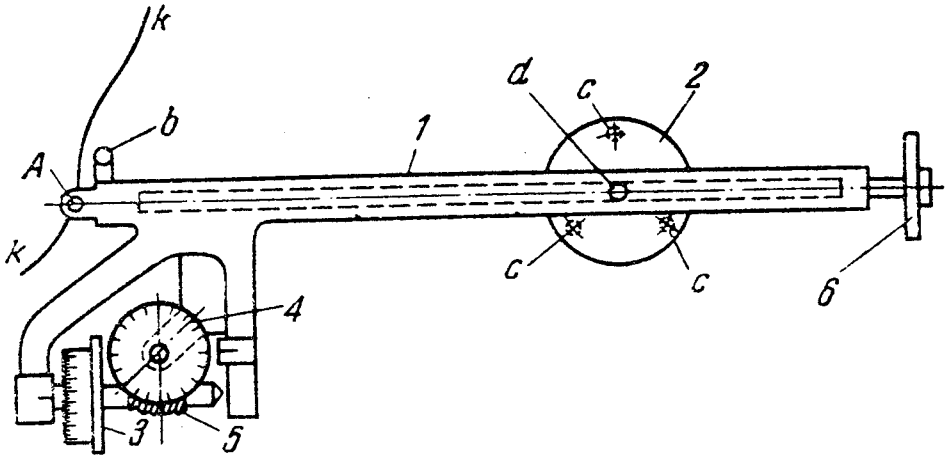



Stylus $A$, fixed on frame *1*, is moved along curve $f(x)$ which is plotted in a coordinate system having its origin at point $O$. This motion along curve $f(x)$ leads to motion of the whole frame which can travel along axes $x$-$x$ and $y$-$y$ by means of guides not shown in the drawing. When stylus $B$ is moved along curve $H(x)$, plotted in a coordinate system with its origin at point $O'$, carriage *2* moves along the vertical guide of frame *1*. At this, stylus *3*, the tracing point of an attached planimeter, slides simultaneously in the slot of carriage *2* and in the slot of guide $a$ which is secured rigidly to frame *1*. Then the measuring wheel of the planimeter gives the value of a function expressed by the equation

$$u = k \oint f(x)\, h(x)\, dx$$

where $k$ is the proportionality factor depending upon the dimensions of the planimeter.

| 1308 | LINK-GEAR INTEGRATOR FOR DETERMINING THE MEAN ARITHMETICAL RADIUS OF ROUND CHARTS | LG MO |
|---|---|---|




When stylus $A$ is moved along curve $k$, link *1* of the integrator slides along pin $d$ of fixed disk *2* and turns through a certain angle $\varphi$. The number of revolutions of measuring wheel *3* is found from the equation

$$n = \frac{1}{2\pi a} \int_0^{\varphi} r \, d\varphi$$

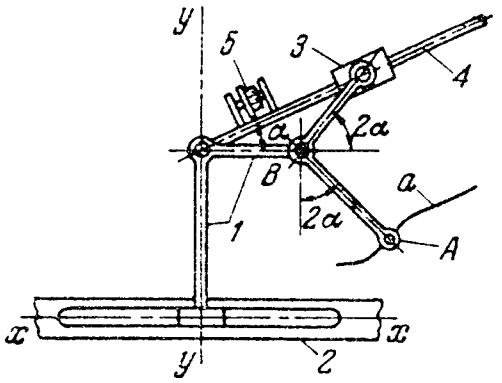
where $a$ = radius of measuring wheel *3*
$r$ = distance from stylus $A$ to the axis of pin $d$, this axis being the origin of coordinates.

Since the mean radius of curvature of curve $k$ is

$$r_m = \frac{1}{\varphi} \int_0^{\varphi} r \, d\varphi \text{ then } r_m = \frac{2\pi}{\varphi} an$$

where $r$ is the instantaneous radius of curve $k$. When stylus $A$ is traced around a closed curve, $r_m = an$. Dial *4*, driven by measuring wheel *3* through worm *5* and a worm wheel rigidly secured to dial *4*, indicates the whole revolutions of wheel *3*, and the circular scale on the wheel indicates the fraction of a revolution. Pin *b*, needle points *c* of disk *2* and roller *6* serve as supports for the integrator.

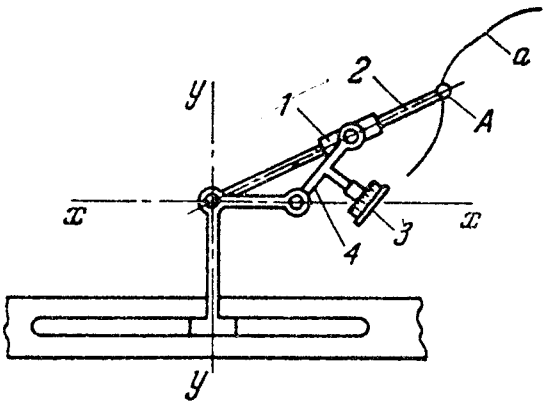
| 1309 | LINK-GEAR INTEGRATOR MECHANISM | LG MO |
|---|---|---|




When stylus $A$ is moved along curve $a$, link *1* slides along slot $x$-$x$ of guiding link *2*, and slider *3* moves along link *4*. The number of revolutions of measuring wheel *5* is proportional to the integral

$$u = \int \sqrt{y}\, dx.$$

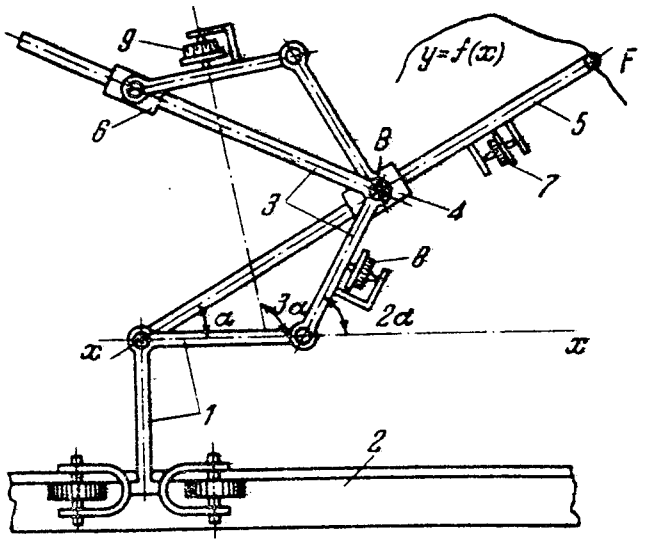
| 1310 | LINK-GEAR INTEGRATOR MECHANISM | LG MO |
|---|---|---|




When stylus $A$ is moved along curve $a$, slider *1* moves along guiding link *2*. The axis of measuring wheel *3* is rigidly secured to link *4* and the number of revolutions of measuring wheel *3* is proportional to the integral

$$u = \int y^2\, dx.$$

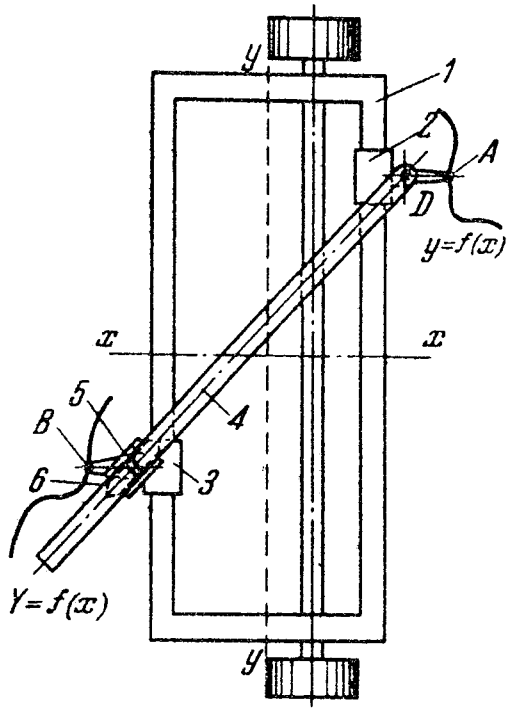
| 1311 | LINK-GEAR THREE-WHEEL INTEGRATOR MECHANISM | LG MO |
|---|---|---|




When stylus $F$ is moved along curve $y = f(x)$, carriage *1* slides along guide link *2*. Bent sliding link *3* turns about pivot $B$, moving slider *4* along link *5*. At this, slider *6* is moved along link *3*. Measuring wheel *7* indicates the area under the curve (between the curve and the $x$-axis), i.e. $A = c \int y\,dx$, where $c$ is a constant of the integrator. Measuring wheel *8* indicates the static moment $M_x = \int y\,dA$. Measuring wheel *9* indicates the quantity

$$I_x = \int y^2\,dA.$$

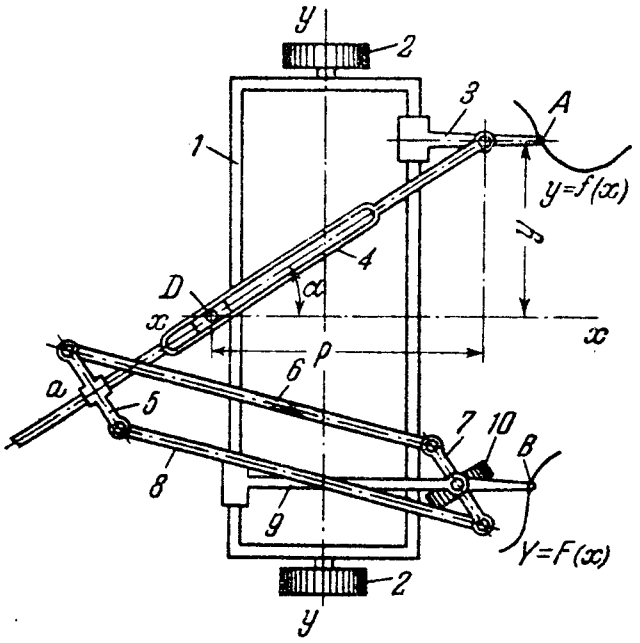
| 1312 | POTIER LINK-GEAR INTEGRAPH MECHANISM | LG MO |
|---|---|---|




When stylus $A$ is moved along curve $y = f(x)$, carriage *1* travels along axis $x$-$x$, and sliders *2* and *3* move along guides of carriage *1* in the direction of axis $y$-$y$. Guiding lever *4* is connected by turning pair $D$ to slider *2* and by a sliding pair to slider *5*. Slider *5* is connected by a turning pair to slider *3* and another turning pair to sharp-edged wheel *6*. The plane of wheel *6* is always parallel to the axis of link *4*. Stylus $B$ traces the integral curve

$$Y = f(x).$$

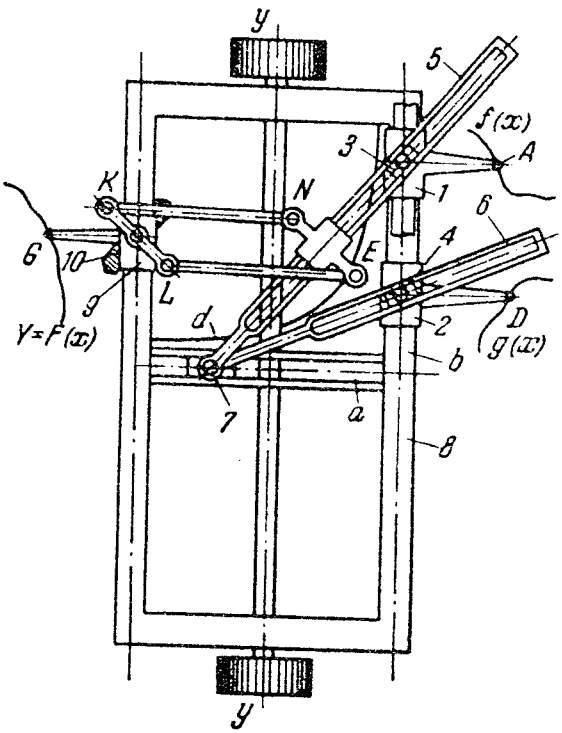
| 1313 | LINK-GEAR INTEGRAPH MECHANISM<br>ABDANK-ABAKANOWICZ-CORADI | LG<br>MO |
|---|---|---|




When stylus $A$ is moved along curve $y = f(x)$, carriage *1* travels along axis $x$-$x$ on rollers *2*. Slider *3* moves along the right-hand guide of carriage *1* in the direction of axis $y$-$y$. At this, slotted link *4* turns about pivot $D$ which is fixed on the carriage. A parallel-crank linkage, consisting of links *5*, *6*, *7* and *8*, moves along slotted link *4* by means of guide bushing *a*. Links *5* and *7* are perpendicular to link *4*. Link *7* is connected by a turning pair to link *9* which slides along the left-hand guide of carriage *1*. Wheel *10* is always parallel to slotted link *4* whose axis makes the angle $\alpha = \arctan \frac{f(x)}{p}$ with the $x$-axis. Therefore, when stylus $A$ is moved along curve $y = f(x)$, wheel *10* describes a curve whose tangent is $Y = \frac{f(x)}{p}$, and stylus $B$ of integrating link *9* describes the integral curve

$$Y = \int \tan \alpha \, dx = \int \frac{y}{p} dx.$$

| 1314 | LINK-GEAR INTEGRAPH MECHANISM | LG MO |
|---|---|---|




When styluses $A$ and $D$, mounted on sliders *1* and *2*, are moved along the corresponding curves $f(x)$ and $g(x)$, sliders *3* and *4* move along the slots of links *5* and *6*. Sliders *3* and *4* are connected to sliders *1* and *2* by turning pairs. Slotted links *5* and *6* are connected by turning pairs to slider *7* which moves along guides *a* of carriage *8*. Sliders *1* and *2* move along the right-hand guide of carriage *8*, parallel to the $y$-axis. Along the left-hand guide, also parallel to the $y$-axis, moves integrating slider *9*. The motion of slider *9* is controlled by wheel *10* which rolls along the plane of the drawing. The plane of wheel *10* is maintained parallel to the axis of slotted link *5* by means of parallel-crank linkage $KNEL$ whose side $NE$ is perpendicular to link *5*. Slotted link *6* slides along guide *d* of hyperbolic shape shown as a line and mounted on frame *8* so that the axis of slot *a* and the axis *b* of the right-hand guide of frame *8* are asymptotes of the hyperbola

$$xy = \frac{1}{4}.$$

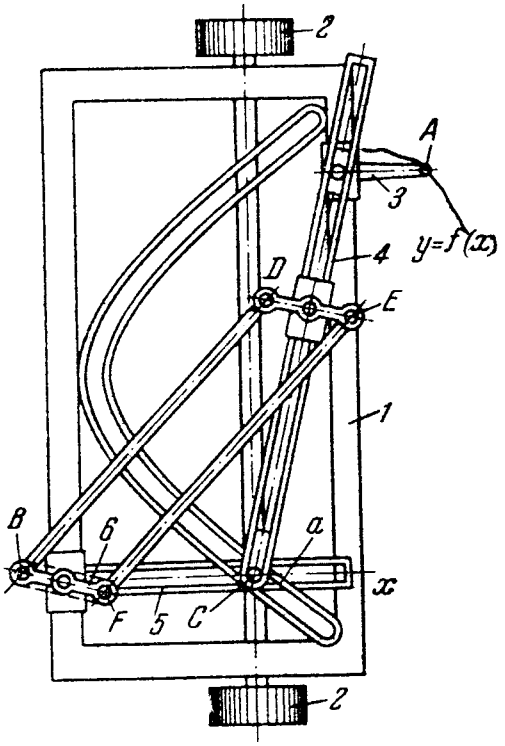
The plane of wheel *10* makes the angle $\varphi$ with the $x$-axis and

$$\tan \varphi = f(x)\, g(x).$$

Stylus $G$ of integrating slider *9* traces the curve

$$F(x) = \int f(x)\, g(x)\, dx.$$

| 1315 | LINK-GEAR INTEGRATOR MECHANISM FOR CALCULATING BALLISTIC TRAJECTORIES OF SHELLS | LG MO |
|---|---|---|




When stylus $A$ is moved along curve $y = f(x)$, carriage *1* travels on rollers *2* along the $x$-axis. Slider *3* moves along the right-hand guide of carriage *1* and slotted link *4* turns about pivot $C$ which slides along guide $a$ of parabolic shape with the equation $x = 1 - y^2$. At this, pin $C$ moves slotted link *5* along the left-hand guide of carriage *1*. By means of parallel-crank linkage $BDEF$, whose side $DE$ is perpendicular to slotted link *4*, the plane of wheel *6* (shown with dash lines) is always perpendicular to link *4*. If guide $a$ is of parabolic shape the mechanism can integrate the equation

$$\frac{dv}{dx} = \frac{v\,[\sin\alpha + \Psi(v)]}{\cos\alpha}$$

where $v$ = velocity of the shell
$\alpha$ = angle of inclination of the trajectory to the horizon
$\Psi(v)$ = velocity function (resistance of the medium divided by the acceleration of gravity).

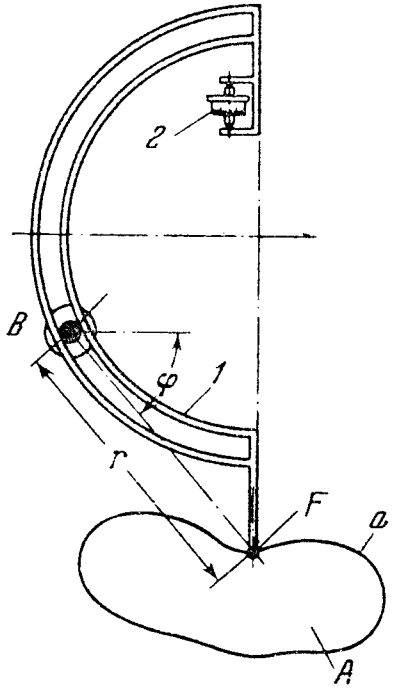
Substituting $v = e^x$ and $y = \sin\alpha$, we obtain

$$\frac{dy}{dx} = \frac{1 - y^2}{f(x) - y}$$

where $f(x) = \Psi(e^x)$.

## 1316 LINK-GEAR PLANIMETER MECHANISM

LG MO

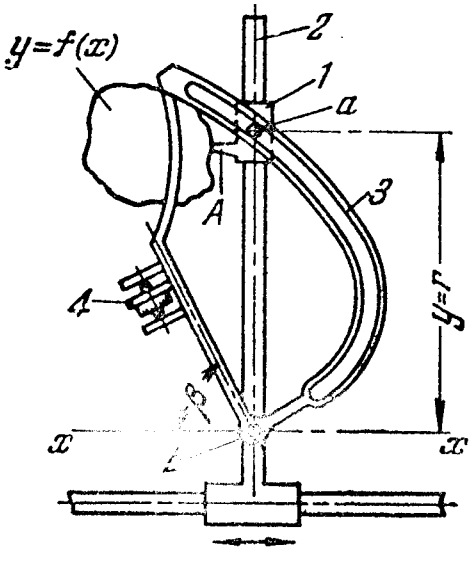



When stylus $F$ is moved around closed curve $a$, slotted link *1* slides along fixed pin $B$. At this, the angle of rotation of measuring wheel *2* is proportional to the area $A$. Thus

$$A = \frac{1}{2} \oint r^2 \, d\varphi.$$

## 1317 LINK-GEAR INTEGRIMETER MECHANISM

LG MO



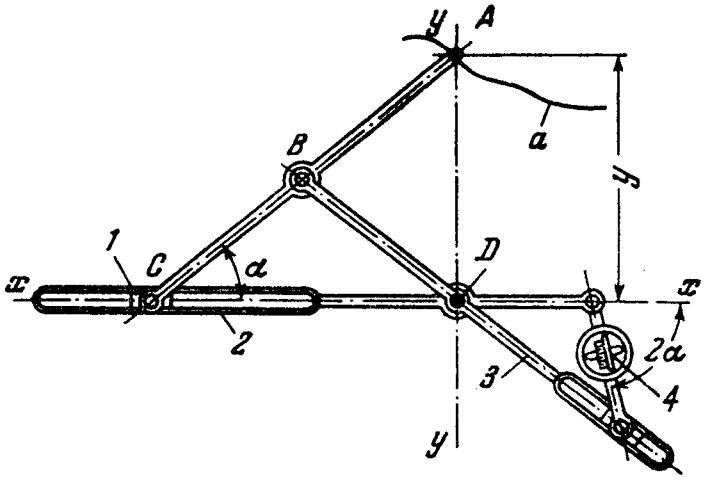

When stylus $A$ is moved along curve $y = f(x)$, slider *1* moves along sliding link *2* which travels with translational motion parallel to axis $x$-$x$. At this, pin $a$ of slider *1* turns slotted link *3* about axis $B$. If the profile of the slot of link *3* is expressed by the equation

$$y = r = r_0 \sqrt[n]{\sin \beta}$$

then the angle of rotation $\varphi$ of measuring wheel *2* is proportional to the quantity

$$\left(\frac{1}{r_0}\right)^n \oint y^n \, dx.$$

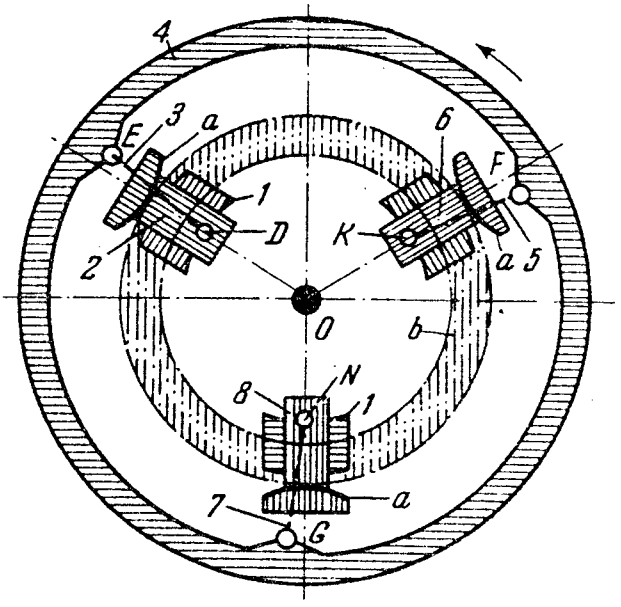
| 1318 | LINK-GEAR INTEGRATOR MECHANISM | LG MO |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AB} = \overline{BC} = \overline{BD} = k$. When stylus $A$ is moved along curve $a$, slider *1* moves along the slot of link *2* and slotted link *3* turns about point $B$. The angle of rotation $\varphi$ of measuring wheel *4* is proportional to the quantity

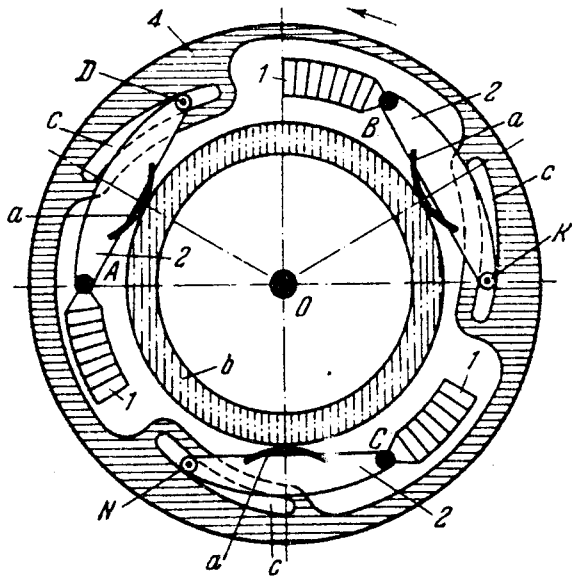
$$(x - x_1) - \left(\frac{1}{2}k^2\right) \int y^2\, dx.$$

| 1319 | LINK-GEAR BRAKE MECHANISM | LG Br |
|---|---|---|



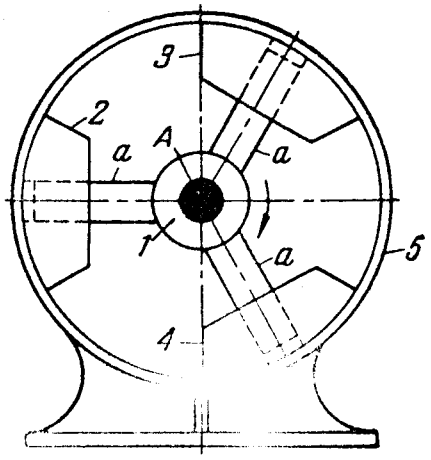

Links *3*, *5* and *7* are connected by turning pairs *E*, *F* and *G* to housing *4* which rotates about fixed axis *O*. Pins *2*, *6* and *8*, with braking members *a*, are connected by sliding pairs to guides *1* which rotate together with housing *4*. Pins *2*, *6* and *8* are connected by turning pairs *D*, *K* and *N* to links *3*, *5* and *7*. When housing *4* is turned counterclockwise with respect to guides *1*, members *a* are pressed against fixed body *b*, thereby braking the housing.

| 1320 | LINK-GEAR BRAKE MECHANISM | LG Br |
|---|---|---|




Links *2*, turning about axes *A*, *B* and *C*, have braking members *a*. Housing *4*, rotating about fixed axis *O*, has curvilinear slots *c* along which rollers *D*, *K* and *N* slide. When housing *4* is turned counterclockwise with respect to links *1*, members *a* are pressed against fixed body *b*, thereby braking the housing.

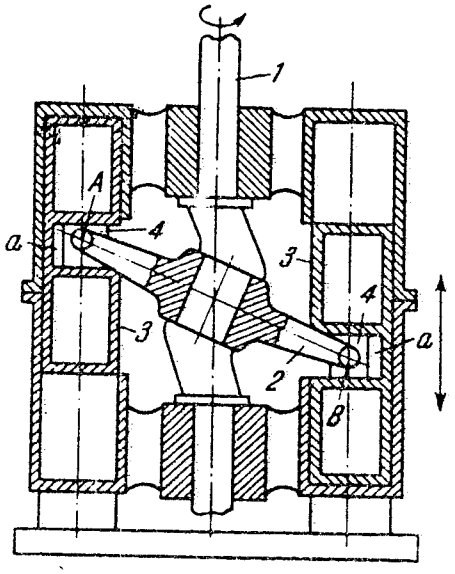
| 1321 | LINK-GEAR MECHANISM OF A CENTRIFUGAL BRAKE | LG Br |
|---|---|---|




Hub *1* is fixed on shaft *A* and carries guides *a* along which shoes *2*, *3* and *4* slide freely. When shaft *A* rotates, shoes *2*, *3* and *4* are forced outward by centrifugal force and are pressed against the rim of fixed pulley *5*, thereby braking the shaft.

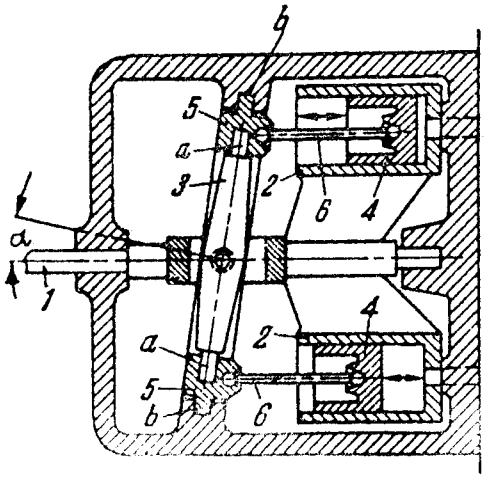
# 9. WOBBLE PLATE MECHANISMS (1322 and 1323)

| 1322 | LINK-GEAR WOBBLE PLATE MECHANISM | LG WP |
|---|---|---|




Double-ended pistons *3* have slots *a* in which sliders *4* reciprocate. Sliders *4* are connected by spherical pairs *A* and *B* to wobble plate *2*. By means of wobble plate *2*, rotation of shaft *1* is converted into reciprocation of pistons *3*.

| 1323 | LINK-GEAR SPHERICAL WOBBLE PLATE MECHANISM | LG WP |
|---|---|---|

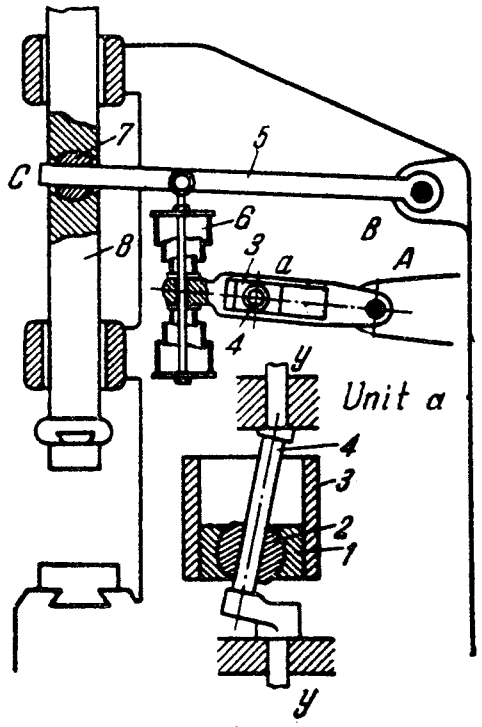



Cylinders *2* are rigidly secured to shaft *1* and rotate together with it. Plate *3* is connected by a turning pair to shaft *1* and its pins *a* fit into holes in ring *5* which slides in fixed guide *b*. Connecting rods *6* are connected on each end by spherical pairs to ring *5* and to pistons *4*. When shaft *1* rotates pistons *4* reciprocate with respect to cylinders *2* and their stroke depends upon the size of angle $\alpha$.

# 10. HAMMER, PRESS AND DIE MECHANISMS (1324 and 1325)

## 1324 LINK-GEAR MECHANISM OF A POWER FORGING HAMMER

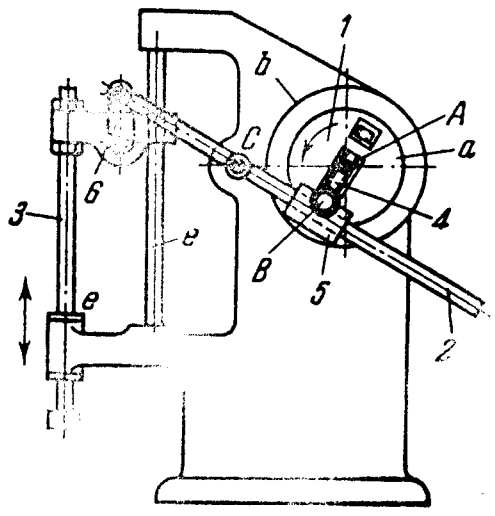
LG HP




The mechanism is driven by angular crank *4* whose design is shown separately (unit *a*). Rotation of crank *4* about axis *y-y*, is converted by slider *1* and spherical sleeve *2* into oscillation of slotted link *3* and lever *5* about fixed axes *A* and *B*. The stroke of the hammer can be varied by adjusting slider *1* along axis *y-y*. Spring *6* is both an elastic link and a shock absorber. Lever *5* is connected at point *C* by a sliding pair to link *7* which is designed as a sphere that turns freely in the hollow spherical surface of link *8*.

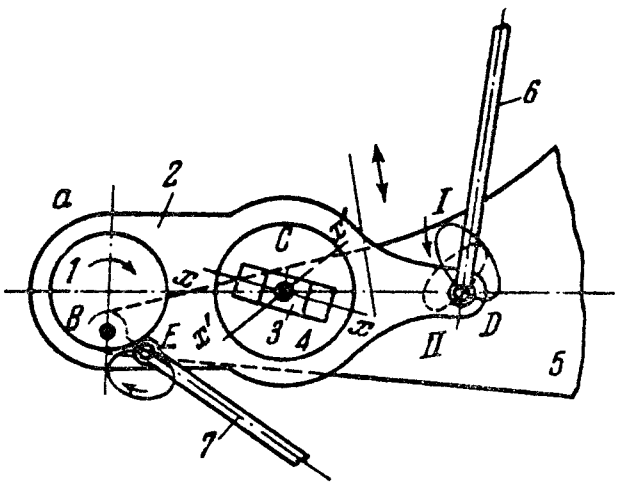
## 1325 LINK-GEAR STAMP MECHANISM

LG HP



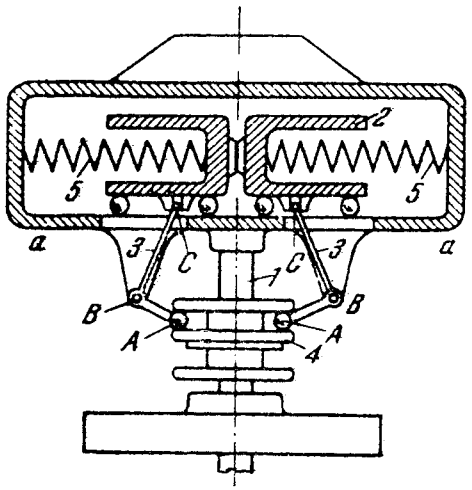

Crank *1*, designed as disk *a* encircled by fixed collar *b*, rotates about fixed axis *A*. Crank *1* is connected by turning pair *B* to slider *5* which, in turn, is connected by a sliding pair to link *2*. Link *2* oscillates about fixed axis *C*. Through intermediate link *6* motion is transmitted from link *2* to link *3* which slides along fixed guides *e*. When crank *1* rotates, link *3* reciprocates. The stroke of link *3* can be varied by screw device *4* which adjusts length $\overline{AB}$ of crank *1*.

| 1326 | ECCENTRIC-TYPE SLOTTED-LINK GOVERNOR MECHANISM | LG G |
|---|---|---|



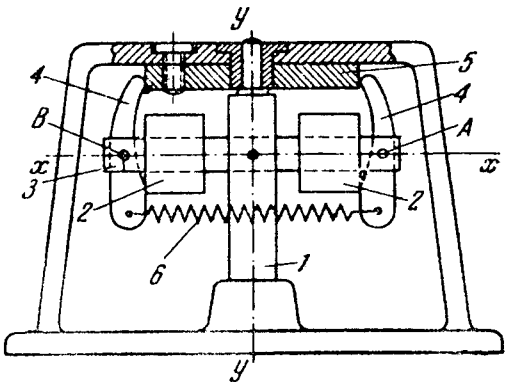

The mechanism is intended for regulating the admission and exhaust of steam. Eccentric cam *1*, rotating about fixed axis *B*, is connected by connecting rod *2* to slider *3* which turns about fixed centre *C*. Connecting rod *2* has collar *a* which encircles eccentric cam *1*. Tie-rods *6* and *7* of the admission and exhaust valves are connected at points *D* and *E* to connecting rod *2*. When eccentric cam *1* rotates, points *D* and *E* move along paths whose position can be varied by changing the angular position of guides *x-x* of slider *3*. This is accomplished by link *4* which is connected to the governor. The two extreme positions of the guides, *x-x* and *x'-x'*, are shown with the corresponding paths of pivot *D*.

| 1327 | LINK-GEAR MECHANISM OF A CENTRIFUGAL GOVERNOR | LG G |
|---|---|---|



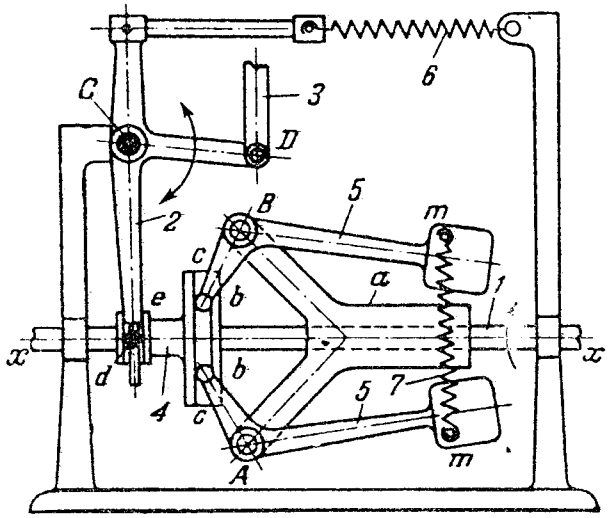

Heavy weights *2* can move in a straight line along guides *a-a*. Links *3*, in the form of bent levers, have spherical surfaces *A* and *C* at their ends. When there is a change in the rotational speed of shaft *1*, weights *2*, moved by centrifugal force in the radial direction, shift link *4* along the axis of shaft *1* by means of levers *3* which turn about axes *B*. In their outward motion, weights *2* overcome the resistance of springs *5*.

| 1328 | LINK-GEAR MECHANISM OF A CENTRIFUGAL GOVERNOR | LG G |
|---|---|---|




Shaft *1*, whose speed is to be governed, rotates about vertical axis *y-y*. Rigidly secured to shaft *1* is bar *3* along whose axis *x-x* weights *2* slide. Pawls *4* turn about axes *A* and *B* of bar *3*. When the rotational speed of shaft *1* increases, weights *2*, moved outward by centrifugal force, press against pawls *4* which turn about axes *A* and *B*, overcoming the tension of spring *6*, so that their upper ends are forced against brake disk *5*.

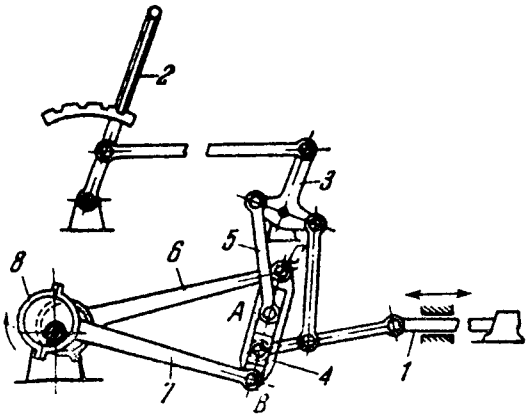
| 1329 | LINK-GEAR MECHANISM OF A CENTRIFUGAL GOVERNOR | LG G |
|---|---|---|




Shaft *1* with its rigidly mounted cross-piece *a* rotates about axis *x-x*. Bent levers *5* turns about axes *A* and *B*. Pins *b* of levers *5* slide along groove *c-c* of sleeve *4* which slides along the *x-x* axis of shaft *1*. Link *2*, turning about fixed axis *C*, has pin *d* which slides along groove *e* of sleeve *4*. Link *3*, connected by turning pair *D* to link *2*, is connected at its other end to the throttle valve. Spring *6* connects link *2* to the upright. Spring *7* links together weights *m* of levers *5*. When the rotational speed of shaft *1* changes, weighted levers *5* shift sleeve *4* along shaft *1*. This turns link *2* which displaces link *3*, thereby changing the setting of the throttle valve.

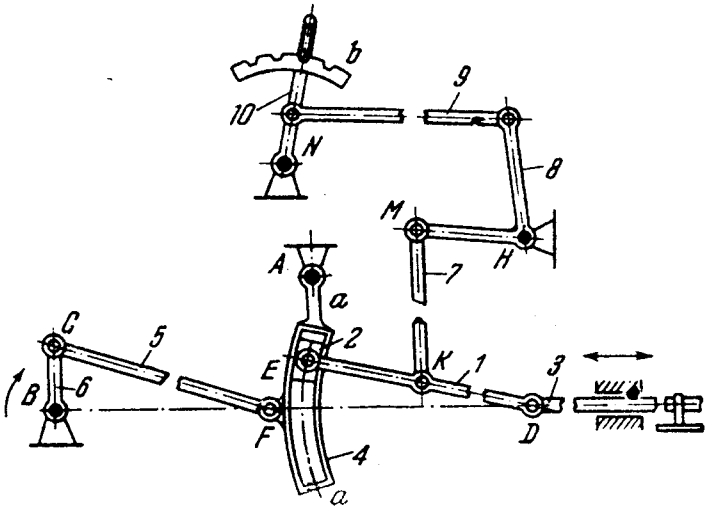
# 12. VALVE GEAR MECHANISMS (1330 through 1336)

| 1330 | LINK-GEAR VALVE GEAR MECHANISM | LG VG |
|---|---|---|



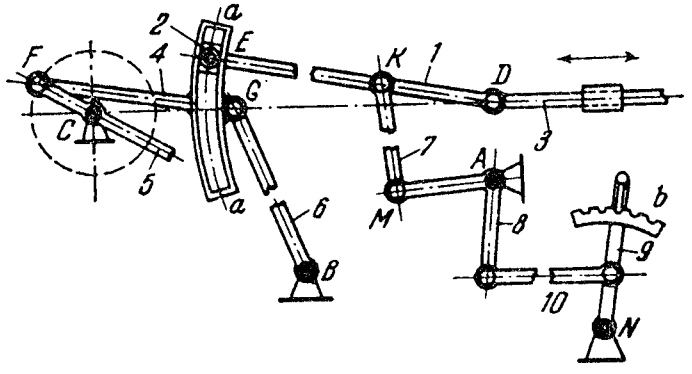

Straight slotted link *4* is connected by turning pairs *A*, *C* and *B* to links *5*, *6* and *7* which are connected, in turn, to link *3* and to eccentric link *8*. For a fixed position of lever *2*, link *3* is stationary. The required stroke of link *1* is obtained by setting lever *2* to the proper position.

| 1331 | LINK-GEAR VALVE GEAR MECHANISM | LG VG |
|---|---|---|



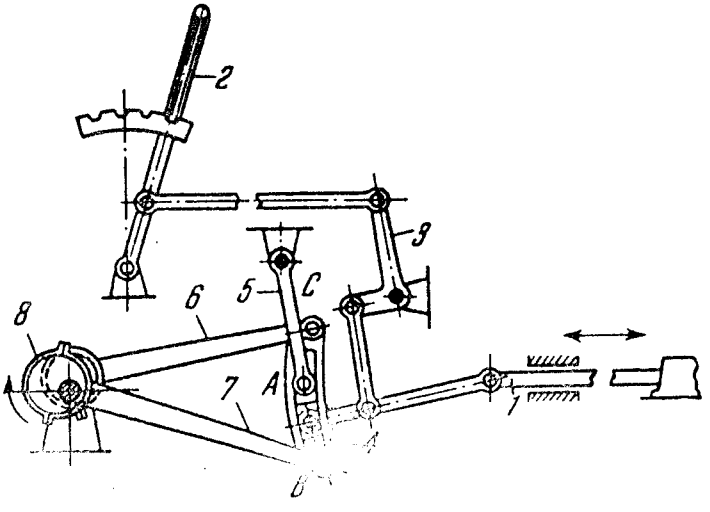

Connecting rod *1* is connected by turning pairs *E* and *D* to circular slider *2* and to rod *3* of the valve. Slider *2* moves along circular guides *a-a* of link *4* which turns about fixed axis *A*. Link *4* is oscillated by connecting rod *5* which is connected by turning pairs *F* and *C* to link *4* and to crank *6*. Crank *6* rotates about fixed axis *B*. Link *7* is connected by turning pairs *K* and [illegible] link *1* and to bent lever *8* which turns [illegible] fixed axis *H*. Lever *8* is connected by intermediate link *9* to lever *10* which turns about fixed axis *N*. The stroke of the valve is varied by setting lever *8* to the proper position and fixing it by means of lever *10* which has a tooth entering one of the slots of toothed quadrant *b*.

| 1332 | LINK-GEAR VALVE GEAR MECHANISM | LG VG |
|---|---|---|



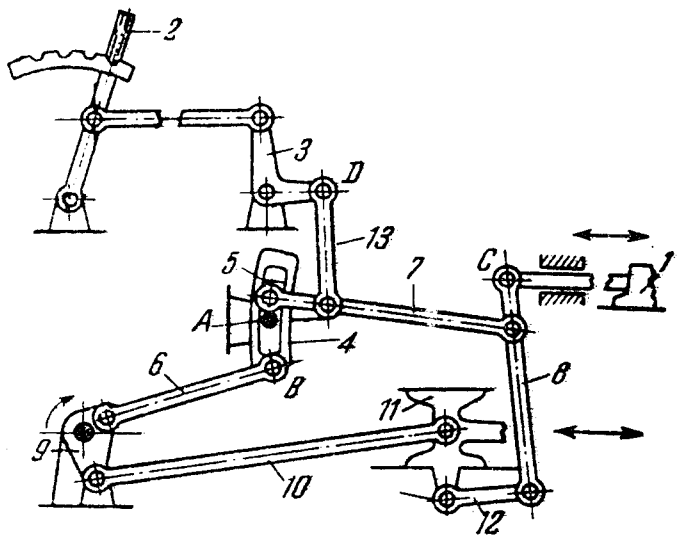

Connecting rod *1* is connected by turning pairs *E* and *D* to circular slider *2* and rod *3* of the valve. Slider *2* moves along circular guides *a-a* of link *4* which is connected by turning pairs *F* and *G* to crank *5* and link *6*. Crank *5* rotates about fixed axis *C* and link *6* turns about fixed axis *B*. Link *7* is connected by turning pairs *K* and *M* to connecting rod *1* and to bent lever *8* which turns about fixed axis *A*. Link *8* is connected by intermediate link *10* to lever *9* which turns about fixed axis *N*. The stroke of valve rod *3* is varied by setting lever *8* to the proper position and fixing it by means of lever *9* which has a tooth entering one of the slots of toothed quadrant *b*.

| 1333 | LINK-GEAR VALVE GEAR MECHANISM | LG VG |
|---|---|---|



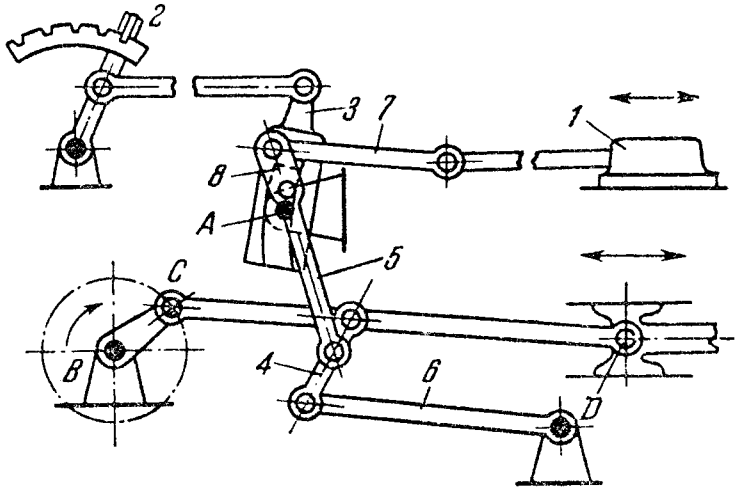

Circular slotted link *4* is connected by turning pairs *A*, *C* and *B* to links *5*, *6* and *7* which are connected, in turn, by turning pairs to the upright and to eccentric link *8*. For a fixed position of lever *2*, link *3* is stationary. The required stroke of link *1* is obtained by setting lever *2* in the proper position.

| 1334 | LINK-GEAR VALVE GEAR MECHANISM | LG VG |
|---|---|---|



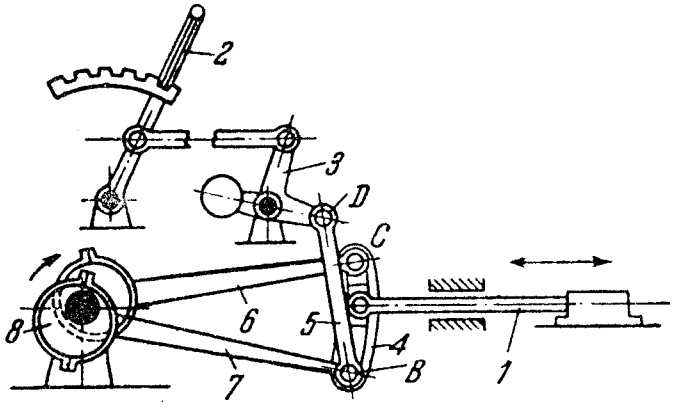

Circular slotted link *4* turns about fixed axis *A* and is connected by a sliding pair to slider *5* which moves along the slot of link *4*. Link *4* is connected by turning pair *B* to link *6*. Slider *5* is connected by a turning pair to link *7*. Link *1* is driven by a system of links *9*, *6*, *4*, *5* and *7* along one kinematic train and a system of links *9*, *10*, *11*, *12* and *8* along another kinematic train. Link *1* is connected by turning pair *C* to link *8*. The required stroke of link *1* is obtained by setting lever *2* in the proper position. Link *3* is then stationary and link *13* turns about axis *D*.

| 1335 | LINK-GEAR VALVE GEAR MECHANISM | LG VG |
|---|---|---|




Circular slotted link *3* turns about fixed axis *A*. The required stroke of link *1* is obtained by setting link *3* in the proper position in which it is fixed by means of lever *2*. Link *1* is reciprocated by crank-and-slider mechanism *BCD* through intermediate links *4*, *5*, *6* and *7*, and slider *8* which moves along circular slotted link *3*.

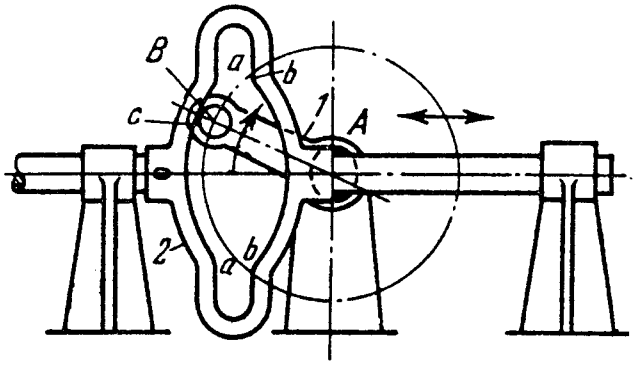
| 1336 | LINK-GEAR VALVE GEAR MECHANISM | LG VG |
|---|---|---|




Circular slotted link *4* is connected by turning pairs *B* and *C* to links *5*, *7* and *6*. Link *5* is connected by turning pair *D* to link *3*, and links *6* and *7* are connected by turning pairs to eccentric crank *8*. For a fixed position of lever *2*, link *3* is stationary. The required stroke of link *1* is obtained by setting lever *2* to the proper position.

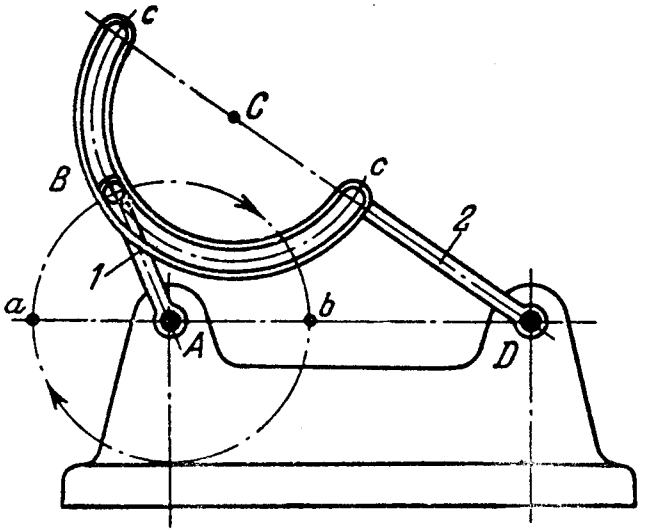
# 13. DWELL MECHANISMS (1337 through 1354)

| 1337 | THREE-BAR SLOTTED-LINK DWELL MECHANISM | LG D |
|---|---|---|



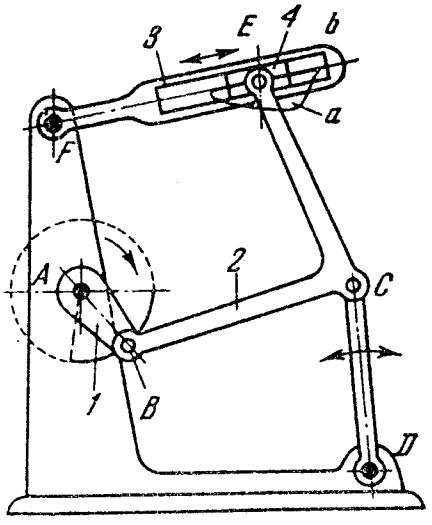

At portions *a-a* and *b-b* reciprocating slotted link *2* has a circular profile of a radius equal to $\overline{AB}$. When roller *c* of crank *1* rolls along arcs *a-a* and *b-b*, slotted link *2* has dwells. To ensure force-applied closure it is necessary to add elastic links such as springs which are not shown.

| 1338 | THREE-BAR SLOTTED-LINK DWELL MECHANISM | LG D |
|---|---|---|



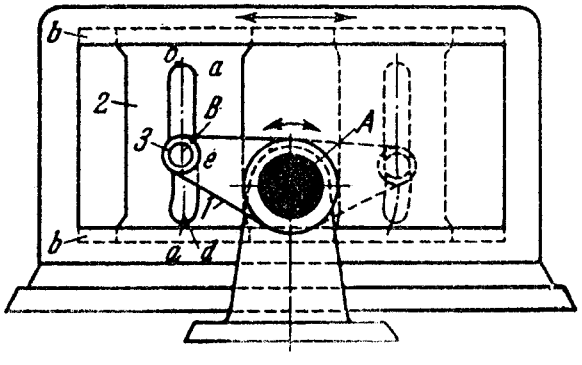

The lengths of the links comply with the conditions: $\overline{AB} = \overline{BC}$ and $\overline{AD} = \overline{DC}$. Link *1*, rotating about fixed axis *A*, has roller *B* which slides along circular guides *c-c* of radius $\overline{CB}$ and with the centre at point [illegible] 2. When crank *1* rotates clockwise, link *2* oscillates while point *B* travels from point *a* to *b*, and has a dwell when it travels from point *b* to *a*. When link *2* oscillates, the mechanism is equivalent to four-bar linkage *ABCD* in which link *AB* is the crank, link *BC* is the connecting rod and link *CD* is the rocker arm.

| 1339 | LINK-GEAR DWELL MECHANISM | LG D |
|---|---|---|



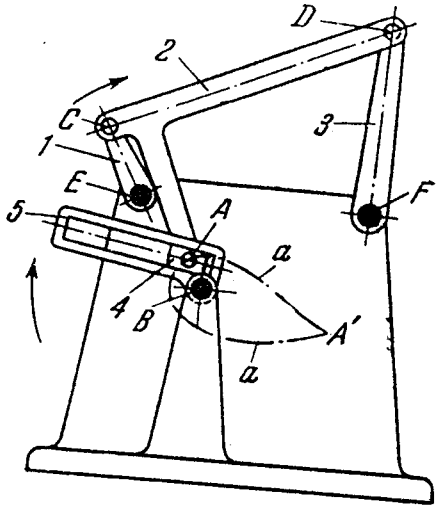

The lengths of the links comply with the conditions: $\overline{AB} = 1$, $\overline{BC} = 3.1$, $\overline{CD} = 2.6$, $\overline{CE} = 3.0$, $\overline{AF} = 2.3$, $\overline{AD} = 4.5$, $\overline{FD} = 6.3$ and $\overline{BE} = 4.0$. Point *E* of connecting rod *2* of the four-bar linkage *ABCD* describes connecting-rod curve *a* of which a certain portion approximates a straight line passing through point *F*. Slotted link *3* turns about fixed axis *F* and has slot *b* whose axis coincides with the straigl t portion of path *a* of point *E*. Slider *4* moves along slot *b*. When point *B* of crank *1* travels along the part of the circle indicated by a heavy continuous line, point *E* of connecting rod *2* moves along the portion of path *a* that approximates a straight line. During this period, slotted link *3* almost ceases to oscillate, i.e. it practically has a dwell.

| 1340 | LINK-GEAR DWELL MECHANISM | LG D |
|---|---|---|




Crank *1*, turning about fixed axis *A*, carries roller *3* which slides along slot *a-a* of slider *2*. Slider *2* moves along fixed guides *b-b*. Portion *ce* of slot *a-a* is straight while portion *ed* is a circular arc of radius $\overline{AB}$. When crank *1* oscillates, link *2* reciprocates with a dwell at one end of its path (shown by dash lines) while roller *3* slides along the circular portion *ed* of slot *a-a*.

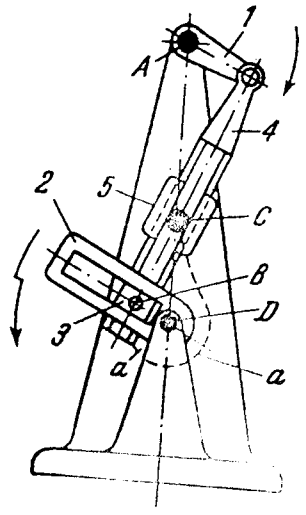
## 1341 LINK-GEAR SHORT DWELL MECHANISM




Point *A* of connecting rod *2* of the four-bar linkage *ECDF* describes connecting-rod curve *a-a*. Slider *4* moves along the slot of slotted link *5* which rotates about fixed axis *B*. Slider *4* is connected by turning pair *A* to connecting rod *2*. During one revolution of crank *1*, slotted link *5* makes one full revolution with a short dwell in the position when point *A* of connecting rod *2* passes through point *A'* of its path *a-a*.

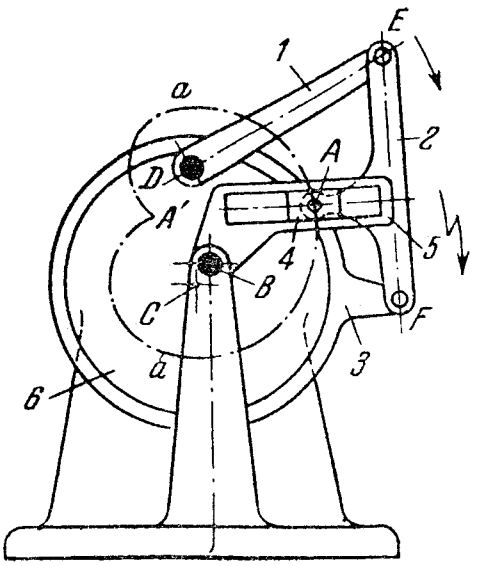
## 1342 LINK-GEAR SHORT DWELL MECHANISM

LG D



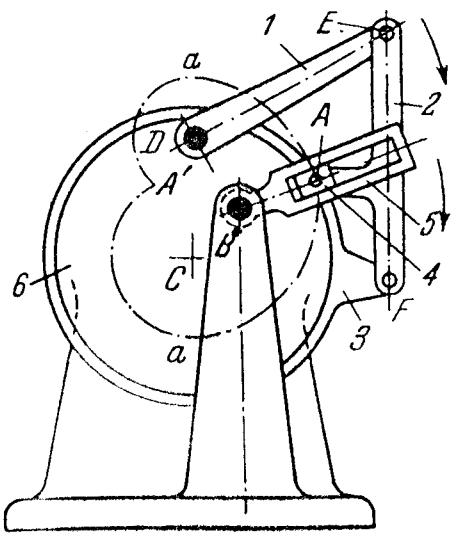

Crank *1* rotates about fixed axis *A* and is connected by a turning pair to connecting rod *4* which slides along guide *5*. Guide *5* turns about fixed axis *C*. Slider *3* moves along the slot of link *2* which turns about fixed axis *D*. Slider *3* is connected by turning pair *B* to connecting rod *4*. Point *B* of connecting rod *4* describes connecting rod curve *a-a*. When crank *1* rotates, slotted link *2* rotates with a short dwell in the position where point *B* of slider *3* passes through the upper point of its path *a-a*.

| 1343 | LINK-GEAR SHORT DWELL MECHANISM | LG D |
|---|---|---|



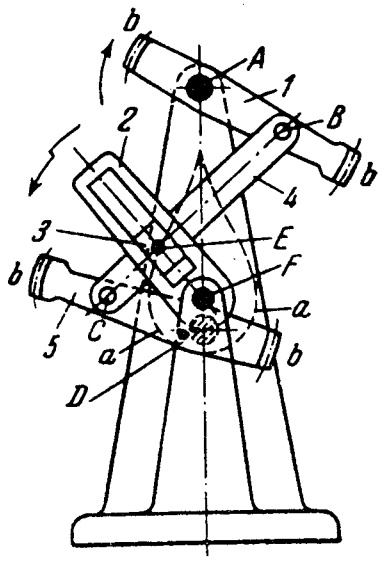

Point *A* of connecting rod *2* of four-bar linkage *DEFC* describes connecting-rod curve *a-a*. Slotted link *5* rotates about fixed axis *B*. Slider *4* moves along the slot of link *5* and is connected by turning pair *A* to connecting rod *2*. Crank *3* is designed as a collar that encircles fixed disk *6* having its centre at point *C*. During one revolution of crank *3*, slotted link *5* makes one complete revolution about centre *B* with a short dwell in the position where point *A* of connecting rod *2* reaches point *A'* of its path. Besides, when point *A* approaches position *A'*, slotted link *5* has a small angular motion in the opposite direction. After this it renews its motion in the previous direction.

| 1344 | LINK-GEAR SHORT DWELL MECHANISM | LG D |
|---|---|---|



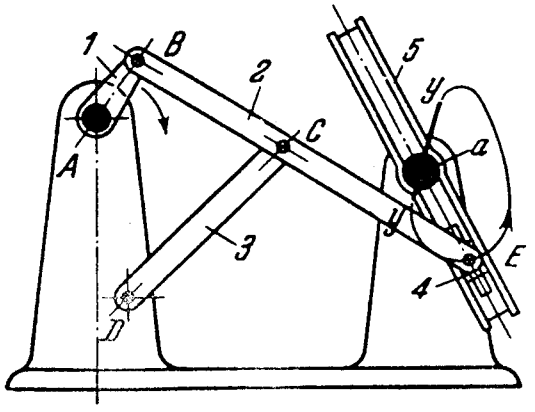

Point *A* of connecting rod *2* of four-bar linkage *DEFC* describes connecting-rod curve *a-a*. Slider *4* moves along the slot of link *5* and is connected by turning pair *A* to connecting rod *2*. Slotted link *5* rotates about fixed axis *B*. Crank *3* is designed as a collar that encircles fixed disk *6* having its centre at point *C*. During one revolution of crank *3*, slotted link *5* makes one complete revolution about its centre *B* with a short dwell in the position where point *A* of connecting rod *2* reaches point *A'* of its path *a-a*.

| 1345 | LINK-GEAR SHORT DWELL MECHANISM | LG D |
|---|---|---|



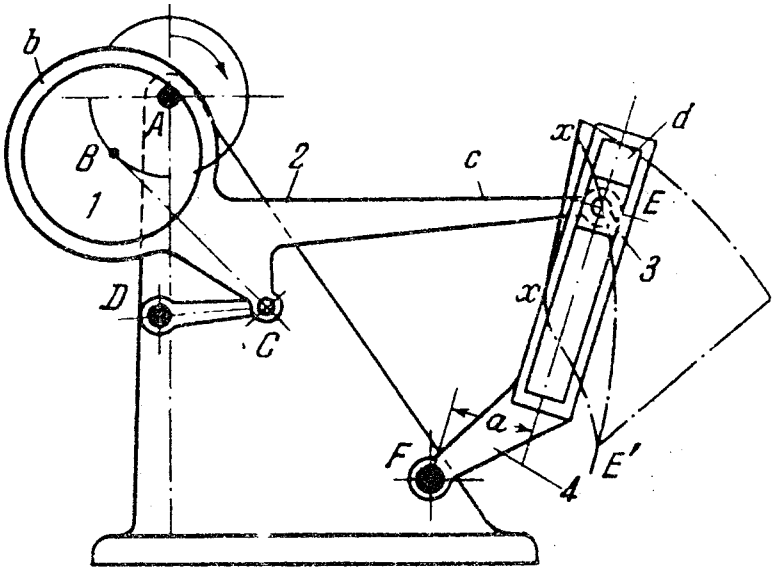

The lengths of the links comply with the conditions: $\overline{AB} = \overline{CD}$ and $\overline{BC} = \overline{AD}$. Figure *ABCD* is a crossed-crank linkage. Slotted link *2*, turning about fixed axis *F*, is connected by a sliding pair to slider *3* which, in turn, is connected by turning pair *E* to connecting rod *4* of crossed-crank linkage *ABCD*. Point *E* of connecting rod *4* describes connecting-rod curve *a-a*. When crank *1* rotates about fixed axis *A*, slotted link *2* rotates about fixed axis *F* with a short dwell when point *E* of slider *3* reaches the upper point of its path *a-a*. Links *1* and *5* have stops *b* to enable the mechanism to pass through its extreme positions (dead centres).

| 1346 | LINK-GEAR DWELL MECHANISM | LG D |
|---|---|---|



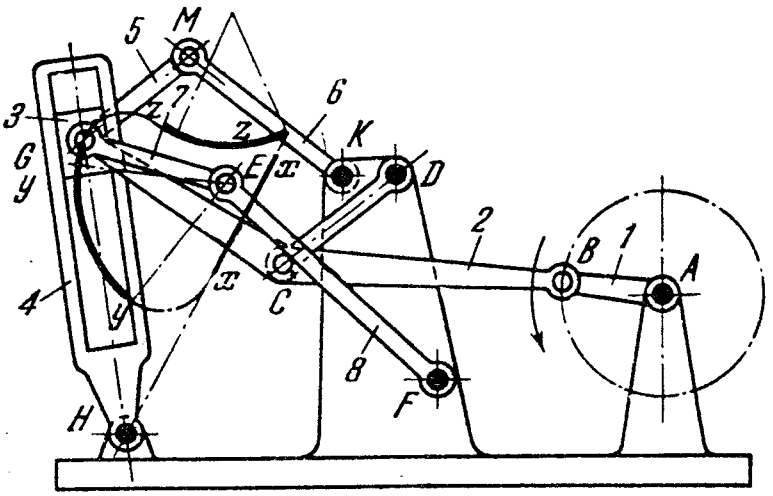

Point *E* of connecting rod *2* of four-bar linkage *ABCD* describes a path of which portion *y-y*, shown by a heavy continuous line, approximates a straight line. When crank *1* rotates about fixed axis *A*, link *2*, connected by turning pair *B* to slider *4*, drives link *5* which rotates with dwells. The dwell of link *5* corresponds to the motion of point *E* of slider *4* along portion *y-y* of its path. Groove *a* of the upright, along which slider *4* travels when linkage *ABCD* is in an extreme (dead centre) position, prevents unintentional motion of link *5* during the dwell period.

| 1347 | ECCENTRIC-TYPE LINK-GEAR DWELL MECHANISM | LG D |
|---|---|---|



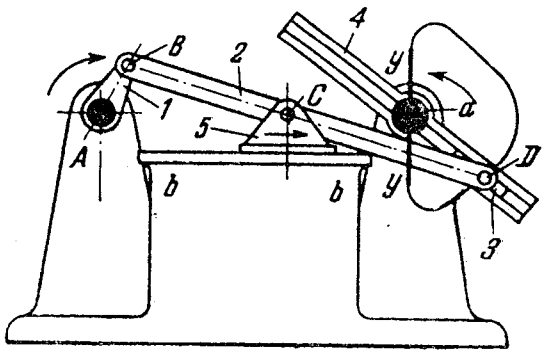

The lengths of the links comply with the conditions: $\overline{CB} \cong \cong 2.66\ \overline{AB}$, $\overline{CD} \cong 1.33\overline{AB}$, $\overline{AD} \cong 2.66\ \overline{AB}$, $\overline{CE} \cong 4.33\overline{AB}$, $\overline{BE} \cong 6.3\ \overline{AB}$, $\overline{AF} \cong 5.66\ \overline{AB}$, $\overline{DF} \cong 4\ \overline{AB}$ and $a = \overline{AB}$. Eccentric *1* has its centre at point *B* and rotates about fixed axis *A*. Connecting rod *2* has collar *b* which encircles eccentric *1*. Projecting lug *c* of connecting rod *2* is connected by turning pair *E* to slider *3* which moves along guides *d* of slotted link *4*. Of the path of point *E* of connecting rod *2*, portion *x-x*, shown by a heavy continuous line, approximates a straight line at a distance of *a* from fixed axis *F* about which link *4* oscillates. When point *E* passes along portion *x-x*, link *4* has a dwell. It also has an instantaneous stop when point *E* reaches position *E'*.

| 1348 | LINK-GEAR DWELL MECHANISM | LG D |
|---|---|---|



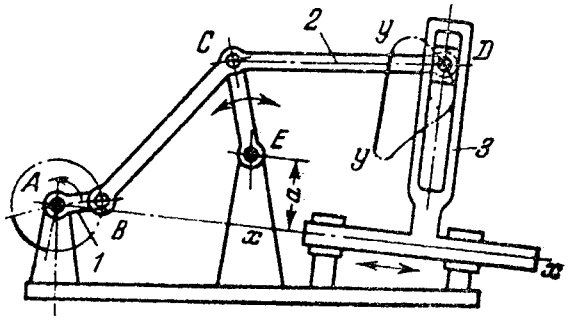

The lengths of the links comply with the conditions: $\overline{BC} = 2.73\overline{AB}$, $\overline{CD} = 1.36\overline{AB}$, $\overline{CG} = 2.32\overline{AB}$, $\overline{BG} = 4.9\overline{AB}$, $\overline{AF} = 2.36\overline{AB}$, $\overline{AD} = 2.87\overline{AB}$, $\overline{DF} = 2\overline{AB}$, $\overline{GE} = 1.45\overline{AB}$, $\overline{EF} = 2.82\overline{AB}$, $\overline{GM} = 1.36\overline{AB}$, $\overline{MK} = 1.91\overline{AB}$, $\overline{KD} = 0.54\overline{AB}$, $\overline{KF} = 2.18\overline{AB}$, $\overline{HF} = 3.1\overline{AB}$ and $\overline{DH} = 3.63\overline{AB}$. The mechanism is based on four-bar linkage *ABCD*. Connecting rod *2* is connected by turning pair *G* to slider *3* which moves along the slot of link *4*. Slotted link *4* turns about fixed axis *H*. Added to linkage *ABCD* are links *5*, *6*, *7* and *8*. Links *5* and *7* are connected together by turning pair *G*. Portion *x-x* of the path described by point *G* of connecting rod *2* approximates a straight line passing through point *H*. Portions *y-y* and *z-z* of the path approximate circular arcs of radii equal to the lengths $\overline{GE}$ and $\overline{GM}$ of links *7* and *5*. These portions are shown by heavy continuous lines. Slotted link *4* has a dwell when slider *3* passes along portion *x-x* of the path of point *G*. Links *6* (*MK*) and *8* (*EF*) have dwells when point *G* passes along portions *z-z* and *y-y*, respectively, of its path.

| 1349 | LINK-GEAR DWELL MECHANISM | LG D |
|---|---|---|




Slider *5* of crank-and-slider linkage *ABC* moves along guides *b-b*. Point *D* of connecting rod *2* describes a path of which portion *y-y*, shown by a heavy continuous line, approximates a straight line perpendicular to guides *b-b*. When crank *1* rotates about fixed axis *A*, link *2*, connected by turning pair *D* to slider *3*, imparts oscillating motion with dwells to slotted link *4*. The dwell of link *4* corresponds to the travel of point *D* of slider *3* along portion *y-y* of its path. Groove *a* of the upright, along which slider *3* travels when linkage *ABC* is in an extreme (dead centre) position, prevents accidental rotation of link *4* during the dwell period.

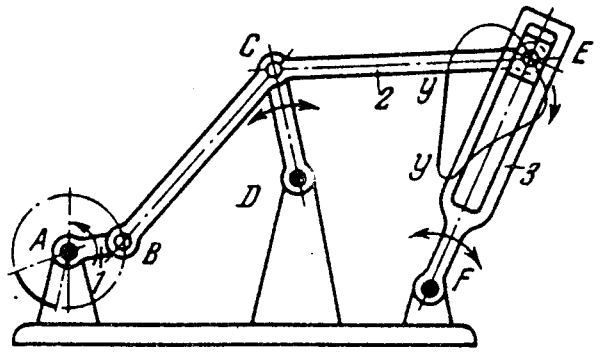
| 1350 | LINK-GEAR DWELL MECHANISM | LG D |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{CB} = 4.28\overline{AB}$, $\overline{CD} = 4.86\overline{AB}$, $\overline{CE} = 2.14\overline{AB}$, $\overline{BD} = 8.4\overline{AB}$, $\overline{AE} = 4.55\overline{AB}$ and $a = 1.66\overline{AB}$. When point *B* of crank *1* travels along the part of a circle indicated by a heavy continuous line, point *D* of connecting rod *2* describes portion *y-y* of its path that is shown by a heavy continuous line and which approximates a straight line perpendicular to guides *x-x*. During continuous rotation of crank *1* about fixed axis *A*, slotted link *3* reciprocates along axis *x-x* with a dwell during the travel of point *D* along portion *y-y* of its path.

## 1351 LINK-GEAR DWELL MECHANISM

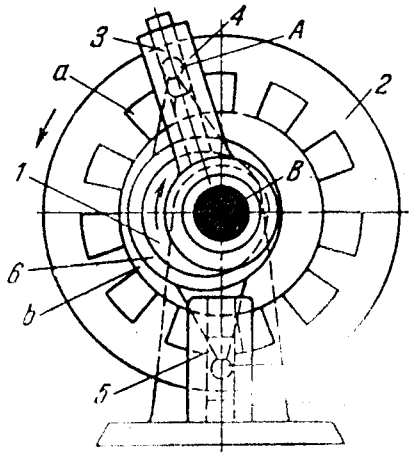
LG D




The lengths of the links comply with the conditions: $\overline{BC} = 4.28\overline{AB}$, $\overline{CE} = 4.86\overline{AB}$, $\overline{BE} = 8.4\overline{AB}$, $\overline{CD} = 2.14\overline{AB}$, $\overline{AD} = 4.55\overline{AB}$, $\overline{AF} = 7\overline{AB}$ and $\overline{DF} = 3.32\overline{AB}$. When point *B* of crank *1* travels along the part of a circle indicated by a heavy continuous line, point *E* of connecting rod *2* describes portion *y-y* of its path that is shown by a heavy continuous line and approximates a straight line passing through point *F*. During continuous rotation of crank *1* about fixed axis *A*, slotted link *3* oscillates about fixed axis *F* with a dwell during the travel of point *E* along portion *y-y* of its path.

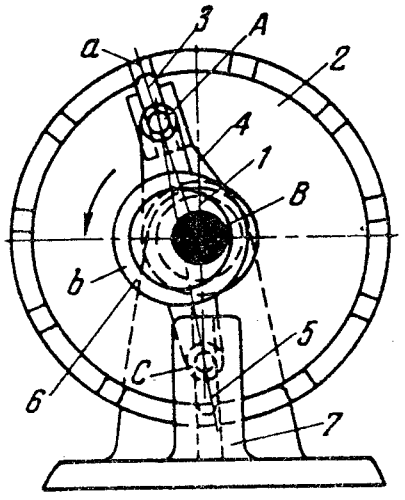
## 1352 ECCENTRIC-DRIVE SLOTTED-LINK INTERMITTENT MOTION MECHANISM

LG D



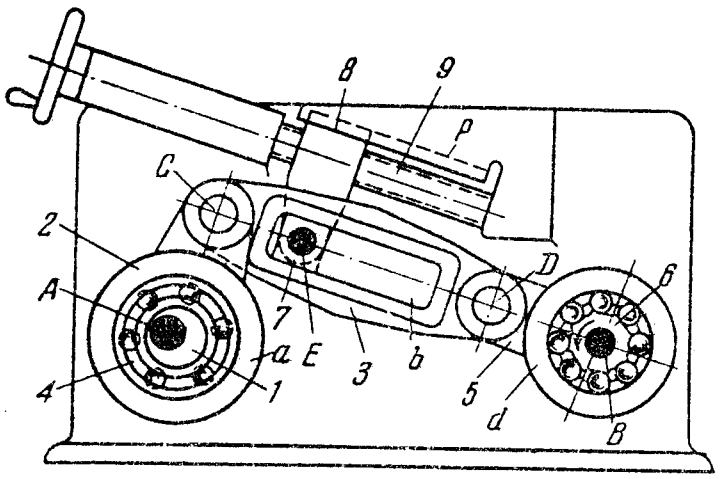

Eccentric *1* rotates about fixed axis *B* and is encircled by collar *b* of link *6*. Link *6* is a two-armed lever. Pin *3* is connected by turning pair *A* to the upper arm of link *6* and slides along guiding link *4* which turns freely about axis *B*. Pin *5* is connected by turning pair *C* to the lower arm of link *6* and slides along fixed guide *7*. When eccentric *1* rotates, the upper arm of link *6* has a complex motion in which pin *3* engages, moves forward and disengages successive slots *a* of member *2* which thereby rotates intermittently, in the opposite direction to eccentric *1*, about axis *B*. While pin *3* disengages one slot *a*, another slot *a* is engaged by pin *5* which holds member *2* stationary until pin *3* engages the next slot.

| 1353 | ECCENTRIC-DRIVE SLOTTED-LINK INTERMITTENT MOTION MECHANISM | LG D |
|---|---|---|




Eccentric *1* rotates about fixed axis *B* and is encircled by collar *b* of link *6*. Link *6* is a two-armed lever. Pin *3* is connected by turning pair *A* to the upper arm of link *6* and slides along guiding link *4* which turns freely about axis *B*. Pin *5* is connected by turning pair *C* to the lower arm of link *6* and slides along fixed guide *7*. When eccentric *1* rotates, the upper arm of link *6* has a complex motion in which pin *3* engages, moves forward and disengages successive grooves *a* of member *2* which thereby rotates intermittently, in the same direction as eccentric *1*, about axis *B*. While pin *3* disengages one slot *a*, another slot *a* is engaged by pin *5* which holds member *2* stationary until pin *3* engages the next slot.

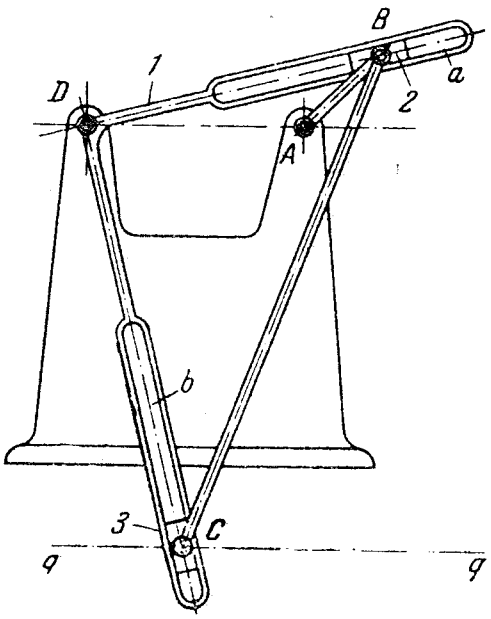
| 1354 | LINK-GEAR STEPLESSLY VARIABLE INTERMITTENT DRIVE MECHANISM | LG D |
|---|---|---|




Link *1* is a circular eccentric rotating about fixed axis *A*. Link *2* has collar *a* encircling eccentric *1* and is connected by turning pair *C* to link *3*. Ball bearing *4* is mounted between eccentric *1* and collar *a*. Slot *b* of link *3* moves along slider *7* which turns about fixed axis *E*. Link *3* is connected by turning pair *D* to link *5* whose housing *d* is a component of overrunning clutch *6*. When eccentric *1* rotates, shaft *B* is driven intermittently by overrunning clutch *6*. The amount the shaft is turned in each revolution of eccentric *1* depends upon the position of axis *E* of link *8* which can be adjusted along guide *p* by screw *9*.

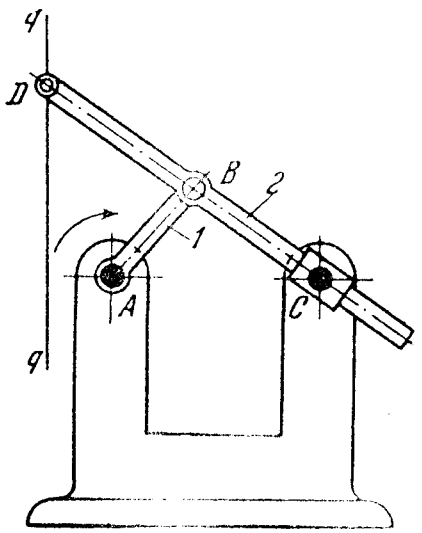
# 14. GUIDING MECHANISMS AND INVERSORS (1355 through 1376)

| 1355 | KOSTITSYN LINK-GEAR APPROXIMATE STRAIGHT-LINE MECHANISM | LG GI |
|---|---|---|



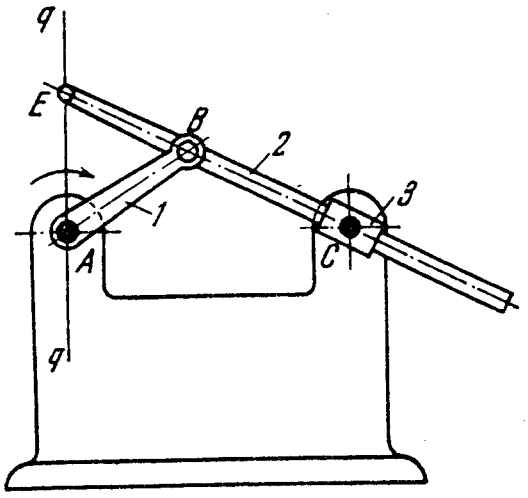

The lengths of the links comply with the conditions: $\overline{AD} = 2\overline{AB}$ and $\overline{BC} = 5\overline{AB}$. Link *1* is a bent lever, turning about fixed axis *D*, with two guiding slots, *a* and *b*, whose axes are perpendicular to each other. Sliders *2* and *3* move along slots *a* and *b*, and are connected by turning pairs *B* and *C* to the same link. When crank *AB* turns about fixed axis *A*, point *C* of slider *3* travels approximately along straight line *q-q* which is parallel to the line of centres *AD*.

| 1356 | FOUR-BAR LINK-GEAR CONCHOIDAL APPROXIMATE STRAIGHT-LINE MECHANISM | LG GI |
|---|---|---|



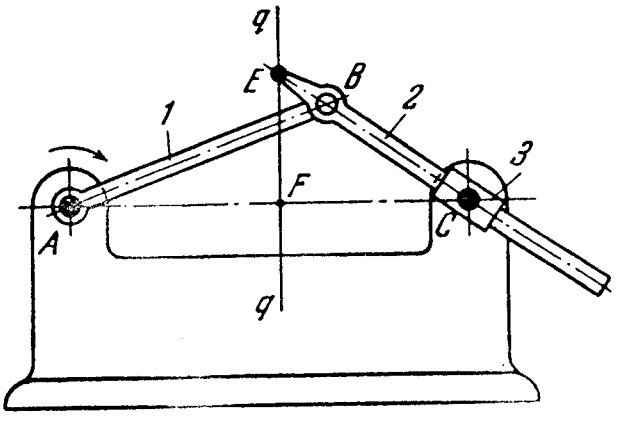

The lengths of the links of link-gear mechanism *ABC* comply with the conditions: $\overline{AC} = 1.81\overline{AB}$ and $\overline{BD} = 1.64\overline{AB}$. When crank *1* turns about fixed axis *A*, point *D* of link *2* describes a path of which a certain portion approximates straight line *q-q* which is perpendicular to the line of centres *AC*.

| 1357 | FOUR-BAR LINK-GEAR CONCHOIDAL APPROXIMATE STRAIGHT-LINE MECHANISM | LG GI |
|---|---|---|



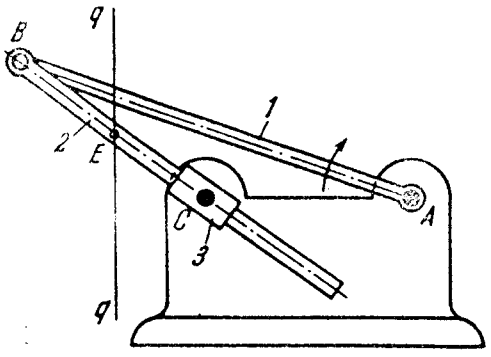

The lengths of the links of link-gear mechanism $ABC$ comply with the conditions: $\overline{AC} = 2\overline{AB}$ and $\overline{AB} = \overline{BE}$. When crank *1* turns about fixed axis $A$, point $E$ of link *2* describes a path of which a certain portion approximates straight line $q$-$q$ passing through point $A$.

| 1358 | FOUR-BAR LINK-GEAR CONCHOIDAL APPROXIMATE STRAIGHT-LINE MECHANISM | LG GI |
|---|---|---|



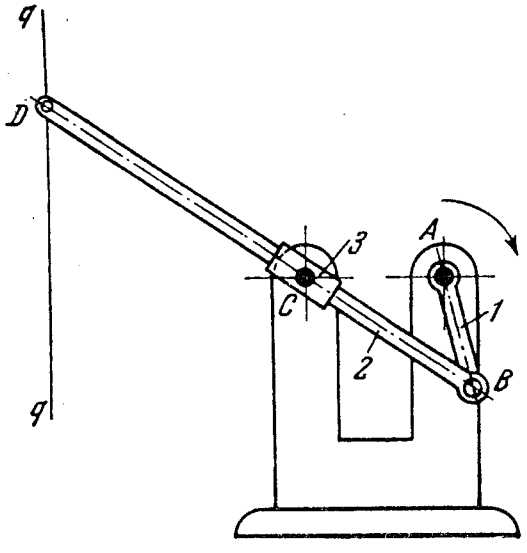

The lengths of the links of link-gear mechanism $ABC$ comply with the conditions: $\overline{AC} = 1.3\overline{AB}$, $\overline{BE} = 0.5\overline{AB}$ and $\overline{CF} = 0.65\overline{AB}$. When crank *1* turns about fixed axis $A$, point $E$ of link *2* describes a path of which a certain portion approximates straight line $q$-$q$ which is perpendicular to the line of centres $AC$.

| 1359 | FOUR-BAR LINK-GEAR CONCHOIDAL APPROXIMATE STRAIGHT-LINE MECHANISM | LG GI |
|---|---|---|



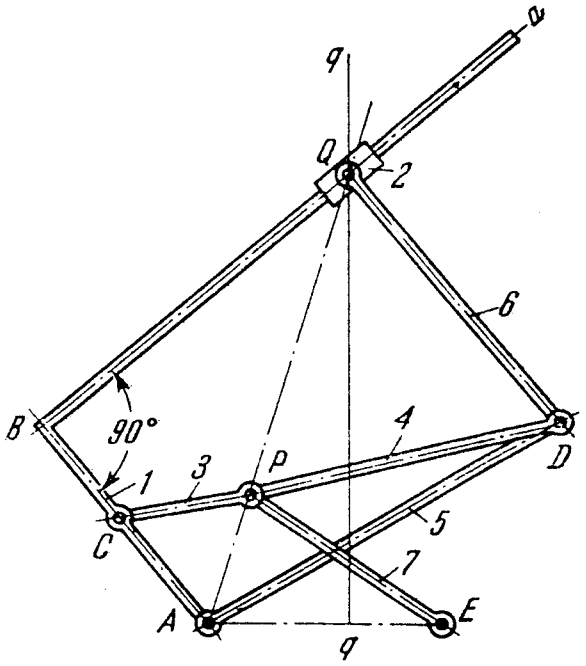

The lengths of the links of link-gear mechanism $ABC$ comply with the conditions: $\overline{AC} = 0.49\overline{AB}$ and $\overline{BE} = 0.28\overline{AB}$. When crank *1* turns about fixed axis $A$, point $E$ of link *2* describes a path of which a certain portion approximates straight line $q$-$q$ which is perpendicular to the line of centres $AC$.

| 1360 | FOUR-BAR LINK-GEAR CONCHOIDAL APPROXIMATE STRAIGHT-LINE MECHANISM | LG GI |
|---|---|---|




The lengths of the links of link-gear mechanism $ABC$ comply with the conditions: $\overline{AC} = 1.5\overline{AB}$ and $\overline{BD} = 5.3\overline{AB}$. When crank *1* turns about fixed axis $A$, point $D$ of link *2* describes a path of which a certain portion approximates straight line $q$-$q$ which is perpendicular to the line of centres $AC$.

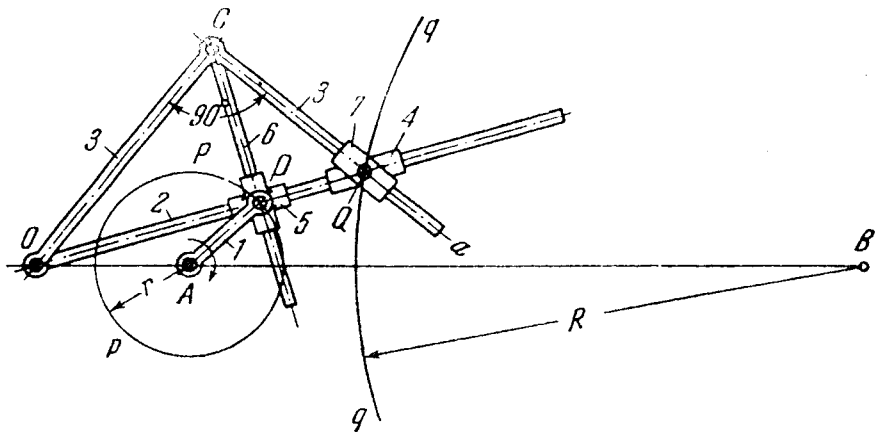
| 1361 | ARTOBOLEVSKY LINK-GEAR STRAIGHT-LINE MECHANISM | LG-GI |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AC} = \overline{CB} = \overline{CP}$, $\overline{PD} = \overline{QD}$ and $\overline{EP} = \overline{EA}$. Link *1* has the form of a bent lever and turns about fixed axis *A*. Arm *Ba* of link *1* moves in slider *2*. Link *3* is connected by turning pairs *C* and *P* to links *1* and *7*. Link *7* turns about fixed axis *E*. Link *4* is connected by turning pairs *P* and *D* to links *7* and *6*. Link *6* is connected by turning pair *Q* to slider *2* and by turning pair *D* to link *5* which turns about axis *A*. The mechanism complies with the inversion condition

$$\overline{AP} \times \overline{QA} = \overline{AB}^2 = \overline{AD}^2 - \overline{PD}^2.$$

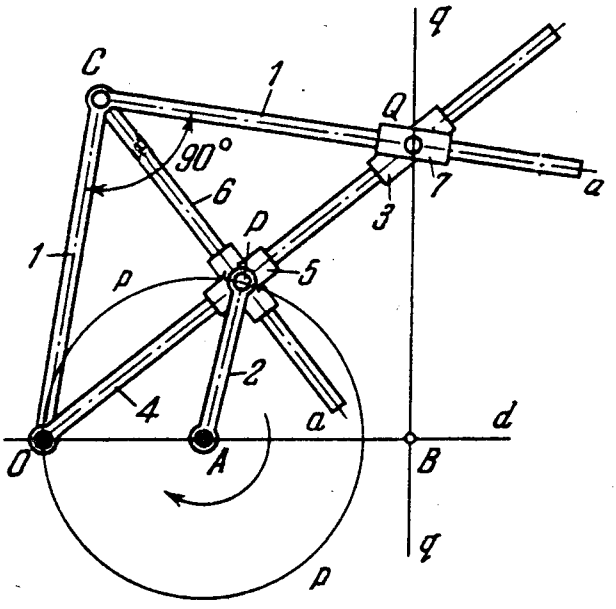
Point *P* describes a circle passing through point *A* of inversion. Point *Q* describes straight line *q-q* which is perpendicular to the line of centres *AE*.




Crank *1* of radius $\overline{AP} = r$ turns about fixed axis *A* and is connected by turning pair *P* to cross-shaped slider *5* which has guides perpendicular to each other. Link *2* turns about fixed axis *O* and is connected by sliding pairs to sliders *5* and *4*. Link *3* has the form of a bent lever and turns about axis *O*. Link *3* is connected by turning pair *C* to link *6* which moves in slider *5*. Arm *Ca* of link *3* moves in slider *7* which is connected by turning pair *Q* to slider *4*. The mechanism complies with the inversion condition $\overline{OP} \times \overline{OQ} = \overline{PC}^2$. Point *P* describes circle *p-p* of radius *r* while point *Q* describes circle *q-q* of a radius equal to $R = \dfrac{\overline{OC}^2 \times r}{\overline{OA}^2 - r^2}$. Centres *A* and *B* of circles *p-p* and *q-q* are determined from the condition

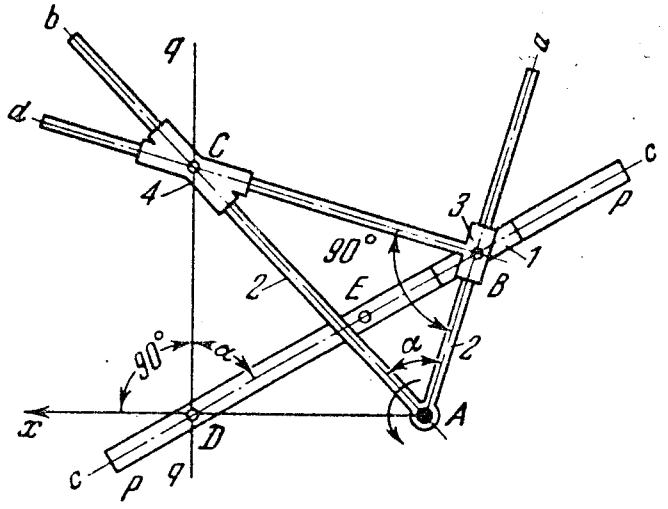
$$\frac{\overline{OB}}{\overline{OA}} = \frac{R}{r}.$$

| 1363 | ARTOBOLEVSKY LINK-GEAR STRAIGHT-LINE MECHANISM | LG GI |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{OA} = \overline{AP}$ and $\overline{OB} = \frac{\overline{OC}^2}{2\overline{OA}}$. Link *2* turns about fixed axis *A* and is connected by turning pair *P* to cross-shaped slider *5* which has guides perpendicular to each other. Link *4* turns about fixed axis *O* and is connected by sliding pairs to sliders *5* and *3*. Link *1* has the form of a bent lever and turns about axis *O*. Link *1* is connected by turning pair *C* to link *6* and its arm *Ca* moves in slider *7*. Link *6* is connected by a sliding pair to slider *5*. Sliders *3* and *7* are connected together by turning pair *Q*. The mechanism complies with the inversion condition, i.e. $\overline{OP} \times \overline{OQ} = \overline{PC}^2$. When link *2* turns about axis *A*, point *P* of slider *5* describes circle *p-p*, and point *Q* of slider *3* describes straight line *q-q* which is perpendicular to the line of centres *OABd* and passes through point *B*.

| 1364 | ARTOBOLEVSKY LINK-GEAR STRAIGHT-LINE MECHANISM | LG GI |
|---|---|---|

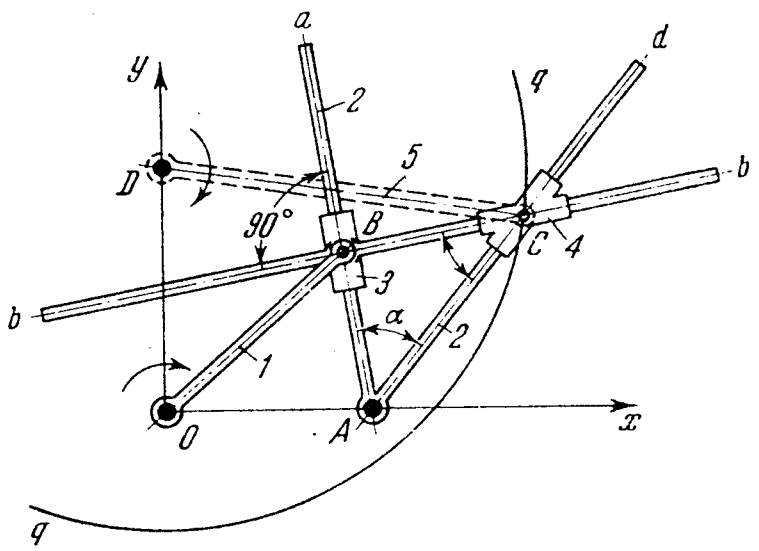



Link *2* has the form of a bent lever and turns about fixed axis *A*. Link *2* is connected by sliding pairs to sliders *3* and *4* which move along its arms *Aa* and *Ab*. Slider *3* is connected by turning pair *B* to slider *1* which moves along fixed guides *p-p*. Cross-piece *Bd* of slider *3* is connected by a sliding pair to X-shaped slider *4* which has guides with axes making the angle $90° - \alpha$ with each other, where $\alpha$ is angle *CAB*. When link *2* turns about axis *A*, point *C*, at the intersection of guides *Bd* and *Ab*, describes straight line *q-q* which is perpendicular to line *Ax*. Line *Ax* makes the angle $90° - \alpha$ with axis *c-c* of guides *p-p*. The distance $\overline{AD}$ equals

$$\overline{AD} = \frac{\overline{AE}}{\cos \alpha}$$

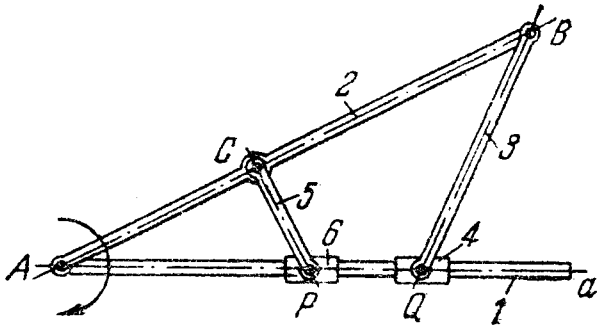
where $\overline{AE}$ is the distance from point *A* to axis *c-c* of guides *p-p*.

| 1365 | ARTOBOLEVSKY LINK-GEAR CIRCLE-TRACING MECHANISM | LG GI |
|---|---|---|




Link *1* turns about fixed axis *O* and is connected by turning pair *B* to slider *3* which moves along arm *Aa* of link *2*. Link *2* has the form of bent lever *aAd* and turns about fixed axis *A*. Cross-piece *b-b* of slider *3* is connected by a sliding pair to X-shaped slider *4* which has guides with axes making the angle $90° - \alpha$ with each other, where $\alpha$ is angle *aAd*. When link *1* turns about axis *O*, point *C*, at the intersection of guides *Ad* and *bb*, describes circle *q-q* of radius $\overline{DC}$. Centre *D* of the circle lies on straight line *Oy* which is perpendicular to axis *Ox*. Distance $\overline{OD}$ is equal to $\overline{OD} = \overline{OA} \times \tan\alpha$. Radius $\overline{DC}$ of circle *q-q* is equal to $\overline{DC} = \dfrac{\overline{OB}}{\cos\alpha}$. The mechanism can be modified by adding link *5* (shown by dash lines) which turns about fixed axis *D* and is connected by turning pair *C* to slider *4*. In this case, the mechanism can transmit rotation from link *1* to link *5* with the transmission ratio $i_{15} = \dfrac{\omega_1}{\omega_5} = 1$. Links *1* and *5* rotate in the same direction.

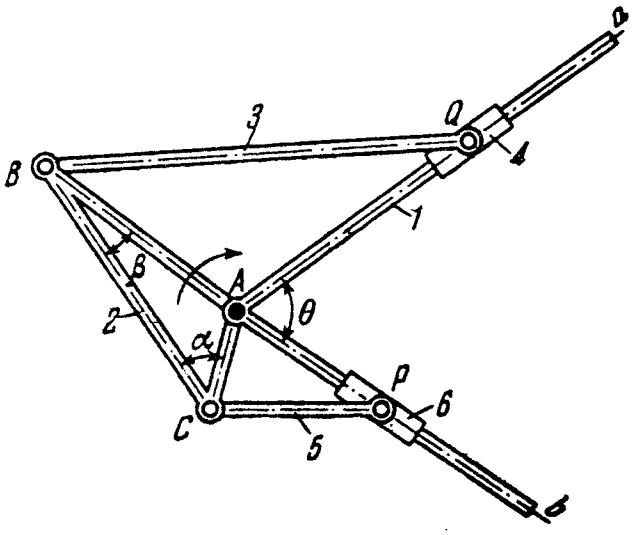
| 1366 | LINK-GEAR TWO-SLIDER INVERSOR MECHANISM | LG GI |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AB} : \overline{AC} = \overline{BQ} : \overline{CP}$. Link *2* turns about fixed axis *A* which is the centre of inversion transformation. Links *3* and *5* are connected by turning pairs *B* and *C* to link *2*, and by turning pairs *Q* and *P* to sliders *4* and *6* which move along axis *Aa* of link *1*. Link *1* turns about axis *A*. When point *P* or *Q* travels along any arbitrary curve, the other point describes a curve which is the inversion of the first curve. Hence, the mechanism accomplishes inversion transformations of the form

$$\overline{AP} \times \overline{AQ} = \overline{AB} \times \overline{AC} = \text{const.}$$

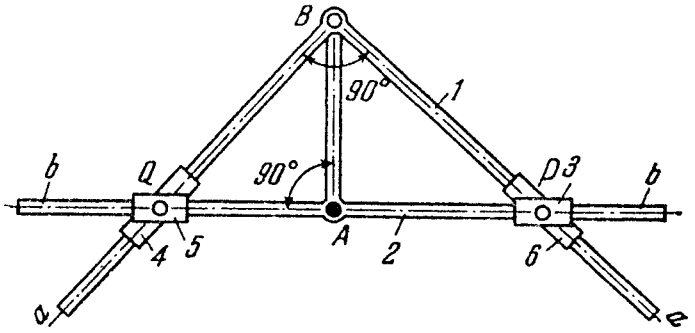
| 1367 | LINK-GEAR TWO-SLIDER INVERSOR MECHANISM | LG GI |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AC} : \overline{AB} = \overline{CP} : \overline{BQ}$ and $\theta = \alpha + \beta$. Link *2* turns about fixed axis *A* which is the centre of inversion transformation. Links *3* and *5* are connected by turning pairs *B* and *C* to link *2* and by turning pairs *Q* and *P* to sliders *4* and *6* which move along arms *Aa* and *Ab* of bent link *1*. Link *1* turns about axis *A*. When point *P* or *Q* travels along any arbitrary curve, the other point describes a curve which is the inversion of the first curve. Hence, the mechanism accomplishes inversion transformations of the form

$$\overline{AP} \times \overline{AQ} = \text{const}.$$

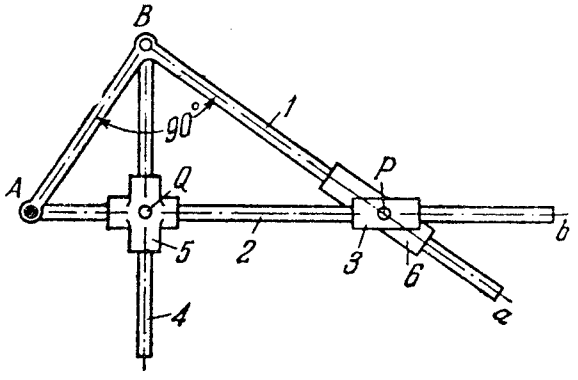
| 1368 | CRAWFORD LINK-GEAR INVERSOR MECHANISM | LG GI |
|---|---|---|




Link *2* has the form of a T-shaped lever and turns about fixed axis *A* which is the centre of inversion transformation. Link *2* is connected by turning pair *B* to bent link *1*. Sliders *3* and *6*, connected together by turning pair *P*, and sliders *4* and *5*, connected together by turning pair *Q*, move along cross-piece *b-b* of link *2* and arm *Ba* of link *1*. For any configuration of the mechanism, points *Q*, *A* and *P* lie on straight line *b-b*. When point *P* or *Q* travels along any arbitrary curve, the other point describes a curve which is an inversion of the first curve. Hence, the mechanism accomplishes inversion transformations of the form

$$\overline{AP} \times \overline{AQ} = \overline{AB}^2 = \text{const.}$$

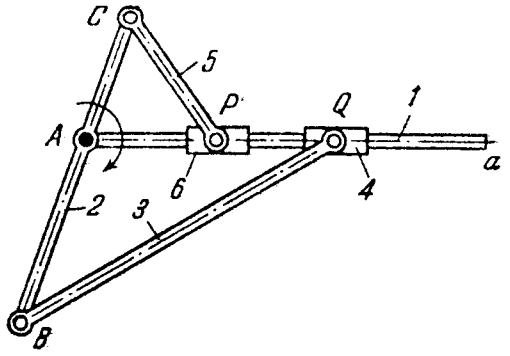
| 1369 | ARTOBOLEVSKY LINK-GEAR INVERSOR MECHANISM | LG GI |
|---|---|---|




Link *2* turns about fixed axis *A* which is the centre of inversion transformation. Link *2* is connected by sliding pairs to slider *3* and to cross-shaped slider *5* which has guides perpendicular to each other. Bent link *1* turns about axis *A* and is connected by turning pair *B* to link *4* which moves in slider *5*. Arm *Ba* of link *1* is connected by a sliding pair to slider *6* which, in turn, is connected by turning pair *P* to slider *3*. For any configuration of the mechanism, points *A*, *Q* and *P* lie on straight line *Ab*. When point *P* or *Q* travels along any arbitrary curve, the other point describes a curve which is the inversion of the first curve. Hence, the mechanism accomplishes inversion transformations of the form

$$\overline{AP} \times \overline{AQ} = \overline{AB}^2 = \text{const.}$$

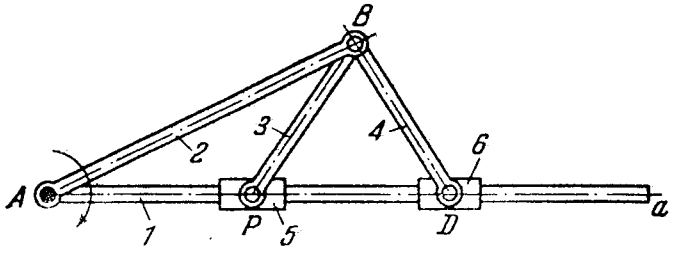
| 1370 | LINK-GEAR TWO-SLIDER INVERSOR MECHANISM | LG GI |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AC} : \overline{BC} = \overline{CP} : \overline{BQ}$. Link *2* turns about fixed axis *A* which is the centre of inversion transformation. Links *3* and *5* are connected by turning pairs *B* and *C* to link *2* and by turning pairs *Q* and *P* to sliders *4* and *6*. Sliders *4* and *6* move along axis *Aa* of link *1* which turns about axis *A*. When point *P* or *Q* travels along any arbitrary curve, the other point describes a curve which is the inversion of the first curve. Hence, the mechanism accomplishes inversion transformations of the form

$$\overline{AP} \times \overline{AQ} = \text{const.}$$

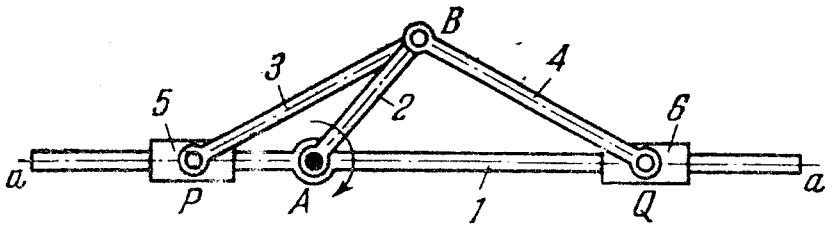
| 1371 | LINK-GEAR TWO-SLIDER INVERSOR MECHANISM | LG GI |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{BP} = \overline{BD}$ and $\overline{AB} > \overline{BP}$. Links *1* and *2* turn about fixed axis *A* which is the centre of inversion transformation. Links *3* and *4* are connected by turning pairs *B* to link *2* and by turning pairs *P* and *D* to sliders *5* and *6* which move along axis *Aa* of link *1*. For any configuration of the mechanism *A*, *B*, *P* and *D* lie on a single straight line. When point *P* travels along any arbitrary curve, the other point describes a curve which is the inversion of the first curve. Hence, the mechanism accomplishes inversion transformations of the form

$$\overline{AP} \times \overline{AD} = \overline{AB}^2 - \overline{BP}^2 = \text{const.}$$

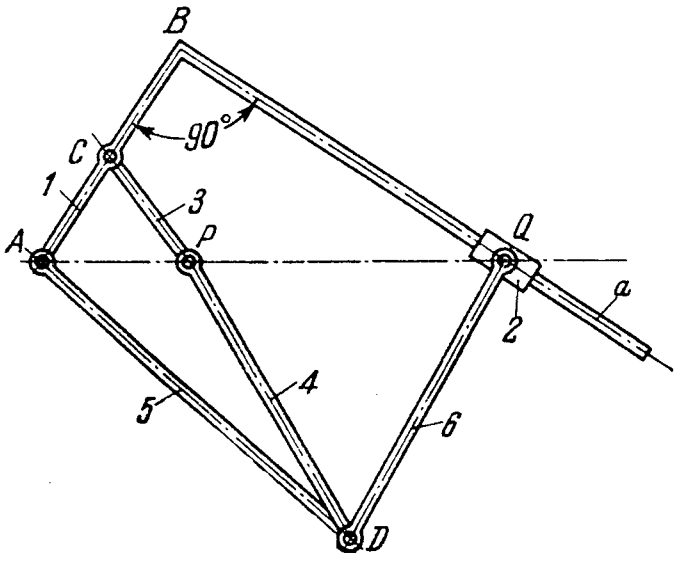
| 1372 | LINK-GEAR TWO-SLIDER INVERSOR MECHANISM | LG GI |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{BP} = \overline{BQ}$ and $\overline{AB} < \overline{BP}$. Links *1* and *2* turn about fixed axis *A* which is the centre of inversion transformation. Links *3* and *4* are connected by turning pairs *B* to link *2* and by turning pairs *P* and *Q* to sliders *5* and *6* which move along axis *a-a* of link *1*. For any configuration of the mechanism points *A*, *P* and *Q* lie on a single straight line. When point *P* or *Q* travels along any arbitrary curve, the other point describes a curve which is the inversion of the first curve. Hence, the mechanism accomplishes inversion transformations of the form

$$\overline{AP} \times \overline{AQ} = \overline{BP}^2 - \overline{AB}^2.$$

| 1373 | ARTOBOLEVSKY LINK-GEAR INVERSOR MECHANISM | LG GI |
|---|---|---|

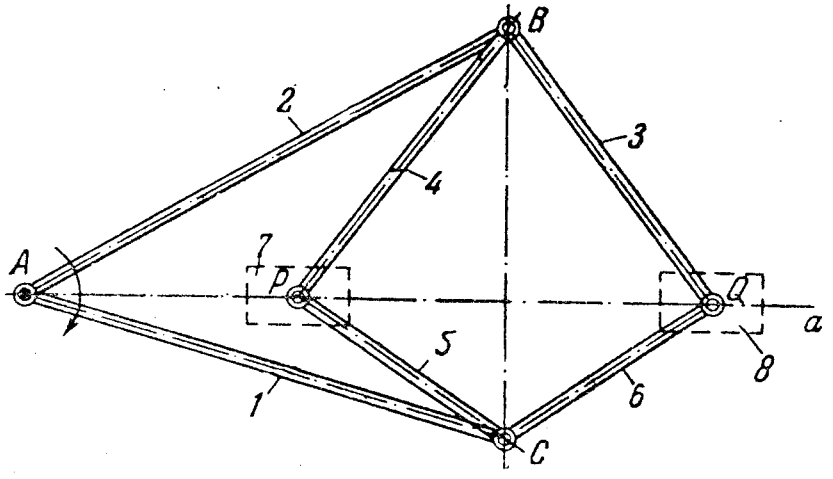



The lengths of the links comply with the conditions: $\overline{AC} = \overline{CB} = \overline{CP}$ and $\overline{PD} = \overline{DQ}$. Links *1* and *5* turn about fixed axis *A*. Link *1* has the form of a bent lever. Arm *Ba* of link *1* moves in slider *2*. Link *3* is connected by turning pairs *C* and *P* to links *1* and *4*. Link *6* is connected by turning pairs *Q* and *D* to slider *2* and to links *4* and *5*. The mechanism complies with the inversion condition

$$\overline{AP} \times \overline{AQ} = \overline{AB}^2 = \overline{AD}^2 - \overline{PD}^2.$$

Therefore, with fixed point *A* as the centre of inversion, when point *P* travels along any arbitrary curve, point *Q* describes a curve which is the inversion of the curve followed by point *P*, and vice versa.

| 1374 | LINK-GEAR RHOMBOID LINKAGE INVERSOR MECHANISM | LG GI |
|---|---|---|

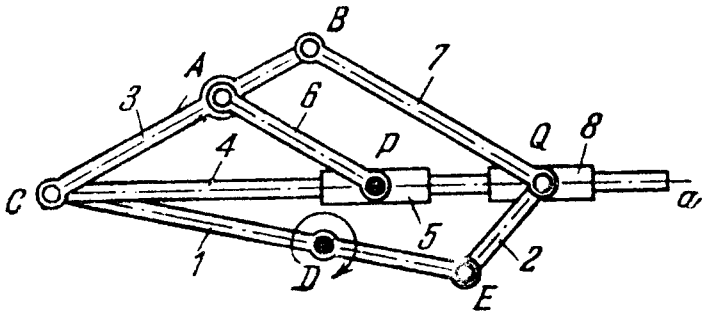



The lengths of the links comply with the conditions: $\overline{AB} = \overline{AC}$, $\overline{BP} = \overline{BQ}$ and $\overline{CP} = \overline{CQ}$. Figure $PBQC$ is a rhomboid linkage. Links *1* and *2* turn about fixed axis $A$ which is the centre of inversion transformation. Links *3* and *4* are connected by turning pairs $B$ to link *2* and by turning pairs $Q$ and $P$ to links *6* and *5*. Links *6* and *5* are connected by turning pairs $C$ to link *1*. For any configuration of the mechanism, points $A$, $P$ and $Q$ lie on straight line $Aa$. When point $P$ or $Q$ travels along any arbitrary curve, the other point describes a curve which is the inversion of the first curve. Hence, the mechanism accomplishes inversion transformations of the form

$$\overline{AP} \times \overline{AQ} = \overline{AB}^2 - \overline{BP}^2 = \overline{AC}^2 - \overline{CP}^2 = \text{const.}$$

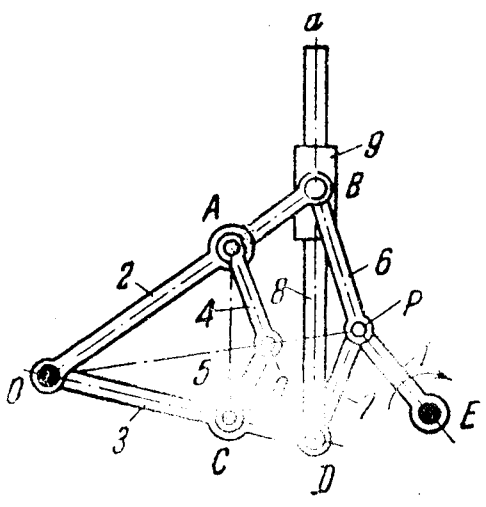
The mechanism is equivalent to either of two link-gear mechanisms, consisting of links *1*, *5*, *6*, *7* and *8*, or of links *2*, *3*, *4*, *7* and *8*, where links *7* and *8* are sliders moving along guiding link $Aa$ which turns about axis $A$. The mechanism accomplishes rectilinear translation of straight line $BC$ which is perpendicular to straight line $APQ$.

| 1375 | LINK-GEAR MECHANISM WITH A TRANSLATIONAL LINK | LG GI |
|---|---|---|




The lengths of the links comply with the condition: $\overline{CB} : \overline{CA} = \overline{BQ} : \overline{AP}$. Points $C$, $P$ and $Q$ lie on a single straight line. Direction $EQ$ of link *2* should be parallel to direction $DP$. Link *1* turns about fixed axis $D$ and is connected by turning pairs $C$ and $E$ to links *3*, *4* and *2*. Link *3* is connected by turning pairs $A$ and $B$ to links *6* and *7* which are connected, in turn, by turning pairs $P$ and $Q$ to sliders *5* and *8*. Sliders *5* and *8* move along axis $Ca$ of link *4*. Link *2* is connected by turning pair $Q$ to slider *8*. When link *1* turns about axis $D$, link *6* has translational motion and all of its points describe circles of radius $\overline{DE}$.

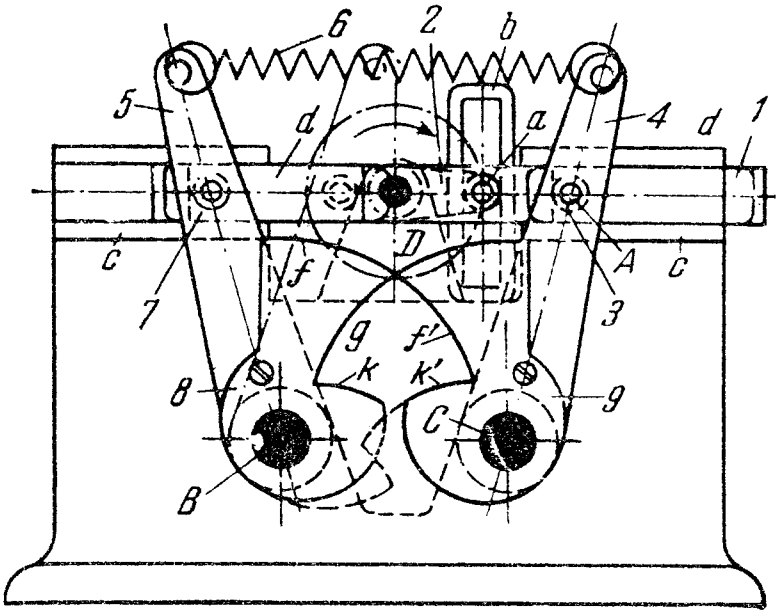
| 1376 | LINK-GEAR MECHANISM FOR OBTAINING TWO PARALLEL DIRECTIONS | LG GI |
|---|---|---|




The lengths of the links comply with the condition: $\overline{OB} : \overline{OA} = \overline{BP} : \overline{AQ} = \overline{OD} : \overline{OC} = \overline{DP} : \overline{CQ}$. Points $O$, $Q$ and $P$ lie on a single straight line. Link *1* turns about fixed axis $E$ and is connected by turning pairs $P$ to links *6* and *7*. Links *2* and *3* turn about fixed axis $O$ and are connected by turning pairs $A$ and $C$ to links *4* and *5*, and by turning pairs $B$ and $D$ to links *6*, *7* and *8* and to slider *9*. Slider *9* moves along axis $Da$ of link *8*. Links *4* and *5* are connected together by turning pair $Q$. When link *1* turns about axis $E$, direction $CA$ is always parallel to axis $Da$ of link *8*.

# 15. SWITCHING, ENGAGING AND DISENGAGING MECHANISMS (1377)

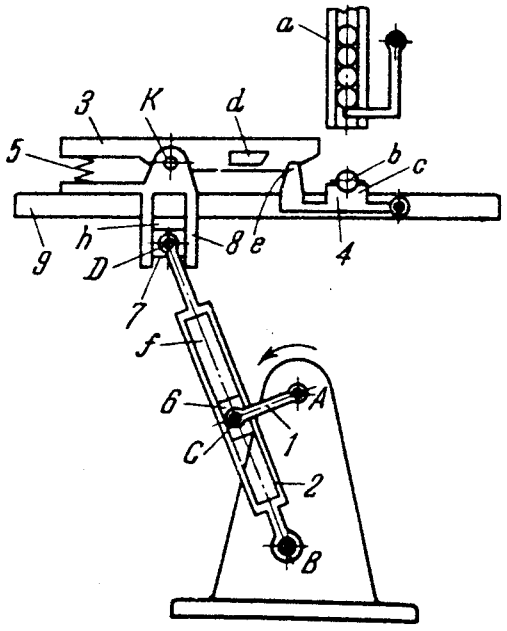
| 1377 | LINK-GEAR CAM-TYPE TENSION-SPRING ENGAGING MECHANISM | LG SE |
|---|---|---|




Crank *2* turns about fixed axis *D* and has roller *a* which moves along slot *b* of slider *1*. Slider *1* reciprocates along guides *c-c* and has grooves *d*. Levers *4* and *5* turn about fixed axes *C* and *B*, and have rollers *3* and *7*. When crank *2* turns clockwise, slider *1* pushes roller *3* to the right, turning lever *4* to its extreme position as shown. At this, spring *6* shifts lever *5* from the position shown to its extreme right-hand position (shown by dash lines). Levers *4* and *5* have cams *9* and *8* whose profiles are made up of circular arcs of equal radii. When slider *1* moves to the right, portion *f* of cam *8* slides along portion *f'* of cam *9*, and in the extreme right-hand position of lever *5*, portion *g* comes into contact with portion *k'*, thereby locking the system. When slider *1* travels in the reverse direction it pushes roller *7* of lever *5*, unlocking this lever. In the extreme left-hand position, portion *f'* comes into contact with portion *k*, after which the cycle is repeated.

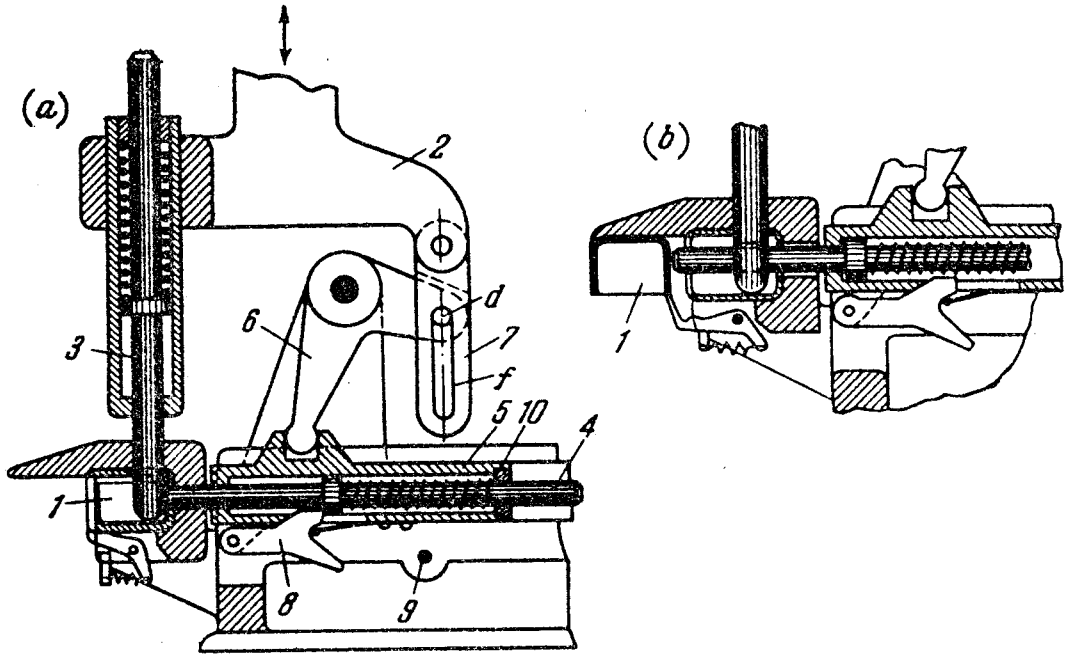
# 16. SORTING AND FEEDING MECHANISMS (1378 through 1381)

| 1378 | LINK-GEAR FEEDING MECHANISM | LG SF |
|---|---|---|



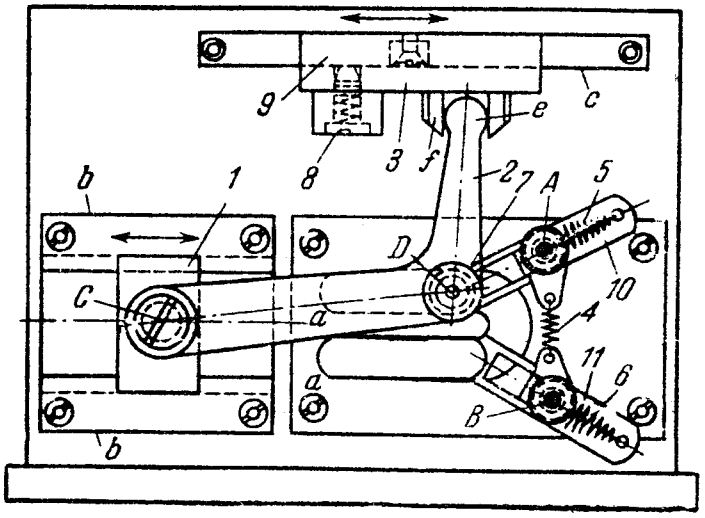

Crank *1* rotates about fixed axis *A* and is connected by turning pair *C* to slider *6* which moves along slot *f* of link *2*. Slotted link *2* oscillates about fixed axis *B* and is connected by turning pair *D* to slider *7* which moves along guide *h* of slider *8*. Slider *8* reciprocates along fixed table *9*. Link *3* is connected by turning pair *K* to slider *8* and is loaded by spring *5*. When crank *1* rotates, slotted link *2* transmits reciprocation to slider *8* and link *3*. When link *3* is in its extreme left-hand position, one workpiece *b* drops out of chute *a* into groove *c* of pawl *4*. When link *3* moves to the right, dog *d*, mounted on link *3*, runs onto lug *e* of pawl *4*, pushing it downward. This releases workpiece *b* which is then held against the datum surface by link *3* actuated by spring *5*.

| 1379 | LINK-GEAR SORTING MECHANISM | LG SF |
|---|---|---|



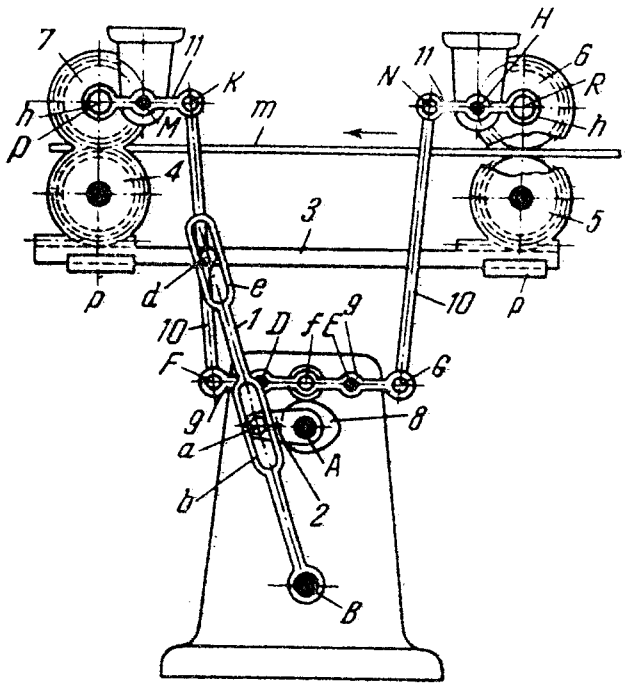

The mechanism is intended for sorting U-shaped blanks *1* so that they are fed into a press in the proper position. Blanks *1* can be fed into feeding disk of the press (not shown) only when they are in the position indicated in Fig. *a*. In this case, plunger *3* reaches the bottom of the blank in the downstroke of cross-member *2*, thereby preventing the ejecting action of horizontal plunger *4*. Plunger *4*, together with slider *5*, is shifted to the left by lever *6* which is turned clockwise by lever *7* when the upper end of its slot *f* pushes pin *d* of lever *6* downward. Latch *8* restricts the stroke of plunger *4*. In the upstroke of cross-member *2*, plunger *4* reaches its extreme right-hand position before plunger *3* is extracted from the blank. At this, latch *8*, moving to the right with slide *5*, runs up against fixed pin *9* and releases plunger *4*. Plunger *4*, actuated by compressed spring *10*, moves to the left, feeding blank *1* into the press. If the next blank is in the same position as in Fig. *a*, then in the downstroke of cross-member *2* horizontal plunger *4* runs against blank *1* clamped by vertical plunger *3* and is shifted to the right with respect to slide *5*, occupying its initial position. If, however, the next blank is admitted in the position indicated in Fig. *b* then, in the downstroke of cross-member *2*, horizontal plunger *4*, moving to the left with slide *5*, ejects the blank. In this case, vertical plunger *3*, which has a slot at its lower end, moves downward, straddling plunger *4* without impeding its motion. In the subsequent cycles, plunger *4* will occupy its extreme left-hand position when a blank is admitted in the position of Fig. *b*, and in its initial position when a blank is admitted in the position of Fig. *a*.

| 1380 | LINK-GEAR FEEDING MECHANISM WITH A DWELL | LG SF |
|---|---|---|




Slider *1* moves along fixed guides *b-b*. Slider *3* moves along fixed guide *c*. Slider *1* is connected by turning pair *C* to bent link *2* which ends in spherical head *e* sliding along slot *f* of slider *3*. Mounted on lever *2* at point *D* is roller *7* which slides and rolls along fixed U-shaped groove *a-a*. The mechanism transforms reciprocating motion of slider *1* into reciprocating motion of slider *3* with a dwell for every other cycle of motion of driving link *1*. By the action of catches *10* and *11*, which turn about fixed axes *A* and *B*, and slide axially, lever *2* is automatically disengaged from and re-engaged to slider *3*. When roller *7* moves along the lower branch of groove *a-a*, slider *3* remains stationary during a full cycle of motion of the driving link. The device consisting of links *8* and *9* serves to stop slider *3* in exactly the same position each time. Springs *4*, *5* and *6* serve to hold catches *10* and *11* in the position shown.

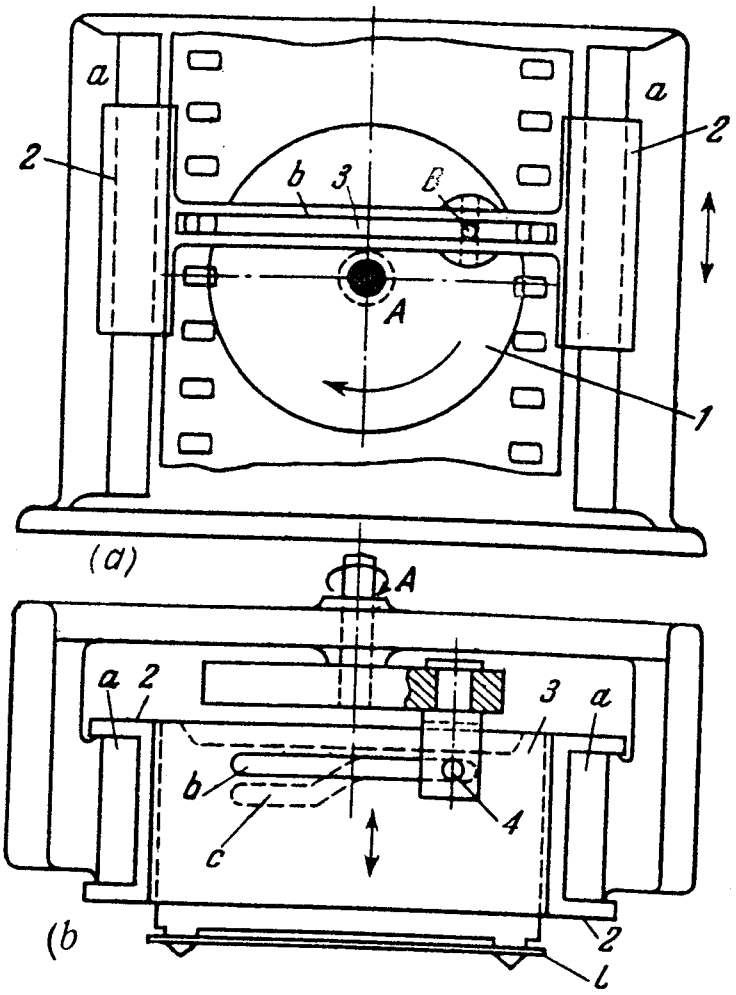
| 1381 | LINK-GEAR ROLL-FEED MECHANISM | LG SF |
|---|---|---|




Crank *2* rotates about fixed axis *A* and has pin *a* which slides along slot *b* of link *1*. Link *1* oscillates about fixed axis *B*. Gear rack *3* slides along fixed guides *p-p* and has pin *d* which slides along slot *e* of link *1*. Rigidly secured to crank *2* is cam *8* which simultaneously actuates two rollers *f* mounted on two levers *9*. Levers *9* oscillate about fixed axes *E* and *D*. Links *10* are connected by turning pairs *G*, *N*, *F* and *K* to links *9* and *11*. Links *11* turn about fixed axes *M* and *H*, and are connected by turning pairs *P* and *R* to rolls *h*. Slotted link *1* is driven by crank *2* which is mounted on shaft *A* of the press. This displaces rack *3* in the horizontal direction. The motion of the rack is transmitted by gears *4*, *5*, *6* and *7* to feeding rolls *h* which are mounted on shafts together with the gears. Rolls *h* feed the strip stock *m* to the die. At the moment the die is closing in the blanking operation, the upper feeding rolls are automatically raised by means of cam *8*, mounted on the press shaft, levers *9*, tie-rods *10* and levers *11*. This interrupts the feeding motion and enables rack *3* to return to its initial position. The amount of feed of stock *m* can be varied by adjusting the position of pin *a*.

# 17. OPERATING CLAW MECHANISMS OF MOTION PICTURE CAMERAS (1382 through 1395)

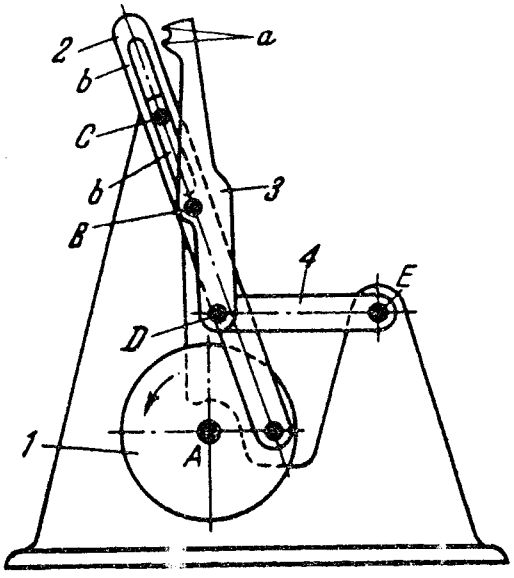
| 1382 | LINK-GEAR OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA | LG OC |
|---|---|---|




Crank *1* (Fig. *a*) is designed as a disk rotating about fixed axis *A*. Pin *B* enters slot *b* of link *2* which slides along fixed guides *a-a*. Link *3* moves along guides of link *2* in a direction perpendicular to the motion of link *2*, as shown in Fig. *b*. The motion of link *3* in this direction is accomplished by means of pin *4* which simultaneously enters slots *b* and *c* of links *2* and *3*. When crank *1* rotates, slotted link *2* and link *3* reciprocate together in the vertical direction. Pin *4*, moving along slots [illegible] periodically [illegible] link *3*, withdraw[illegible] the claws from [illegible]ngement with [illegible] *l*.

## 1383 SLOTTED-LINK OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA

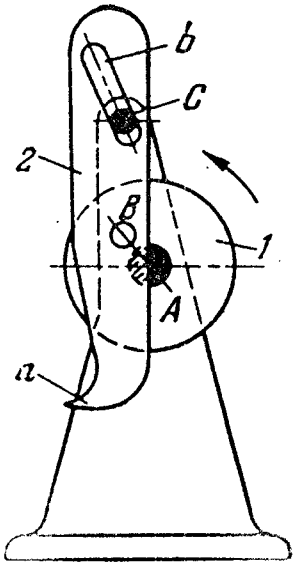
LG
OC




Connecting rod *2* has slot *b-b* sliding along fixed pin *C*. Link *3* is connected by turning pair *B* to connecting rod *2* and by turning pair *D* to link *4* which turns about fixed axis *E*. When crank *1* rotates about fixed axis *A*, the tips of claws *a* of link *3* describe complex connecting-rod curves. At one of the portions of these curves, the claws are inserted into perforations of the film which they advance. At another portion of the curves, claws *a* are withdrawn from the perforations.

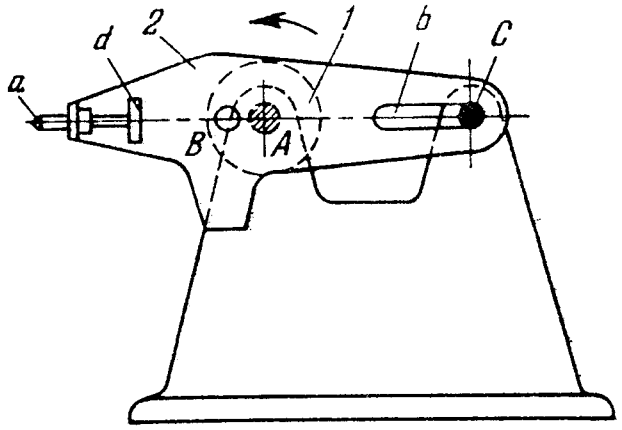
## 1384 THREE-BAR SLOTTED-LINK OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA

LG
OC



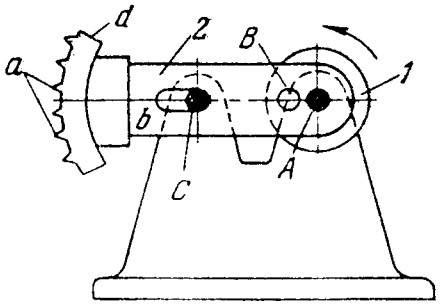

Link *1* of slotted-link mechanism *ABC* rotates about fixed axis *A*. Slotted link *2* is connected by turning pair *B* to link *1* and has slot *b* sliding along fixed pin *C*. The axis of slot *b* does not pass through point *B*. When crank *1* rotates about axis *A*, the tip of claw *a*, mounted on slotted link *2*, describes a connecting-rod curve in which claw *a* is inserted into a perforation of the film, advances the film and is withdrawn from the perforation.

| 1385 | THREE-BAR SLOTTED-LINK OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA | LQ OC |
|---|---|---|




Link *1* of slotted-link mechanism *ABC* rotates about fixed axis *A*. Slotted link *2* is connected by turning pair *B* to link *1* and has slot *b* sliding along fixed pin *C*. The axis of slot *b* passes through point *B*. When crank *1* rotates about axis *A*, the tip of pin *a* of slotted link *2* describes a connecting-rod curve in which the pin is inserted into a perforation of the film, advances the film and is withdrawn from the perforation. The position of the pin is adjusted by screw *d*.

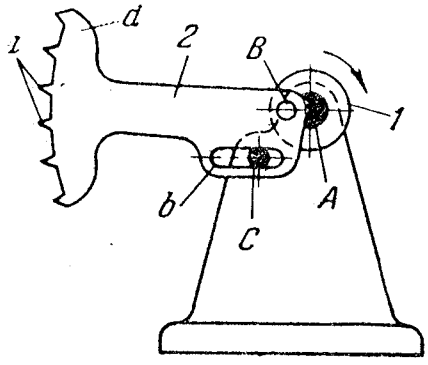
| 1386 | THREE-BAR SLOTTED-LINK MOTION PICTURE CAMERA OPERATING CLAW MECHANISM WITH A TOOTHED SEGMENT | LG OC |
|---|---|---|




Link *1* of slotted-link mechanism *ABC* rotates about fixed axis *A*. Slotted link *2* is connected by turning pair *B* to link *1* and has slot *b* sliding along fixed pin *C*. The axis of slot *b* passes through point *B*. Mounted on slotted link *2* is toothed segment *d*. When crank *1* rotates about axis *A*, the tips of claws *a* of segment *d* describe connecting-rod curves in which claws *a* are inserted into perforations of the film, advance the film and are withdrawn from the perforations.

## 1387 THREE-BAR SLOTTED-LINK MOTION PICTURE CAMERA OPERATING CLAW MECHANISM WITH A TOOTHED SEGMENT

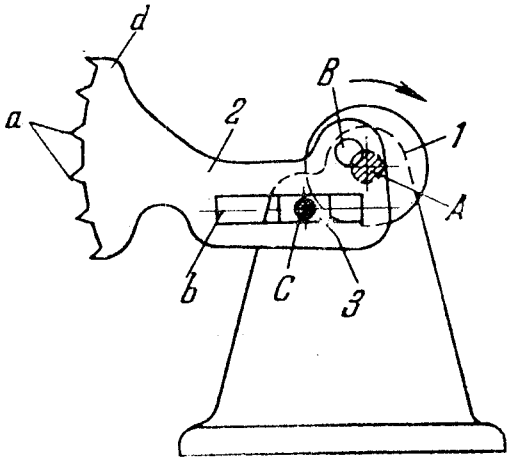
LG
OC




Link *1* of slotted-link mechanism *ABC* rotates about fixed axis *A*. Slotted link *2* is connected by turning pair *B* to link *1* and has slot *b* sliding along fixed pin *C*. The axis of slot *b* does not pass through point *B*. Mounted on slotted link *2* is toothed segment *d*. When crank *1* rotates about axis *A*, the tips of claws *a* of segment *d* describe connecting-rod curves in which claws *a* are inserted into perforations of the film, advance the film and are withdrawn from the perforations.

## 1388 FOUR-BAR SLOTTED-LINK MOTION PICTURE CAMERA OPERATING CLAW MECHANISM WITH A TOOTHED SEGMENT

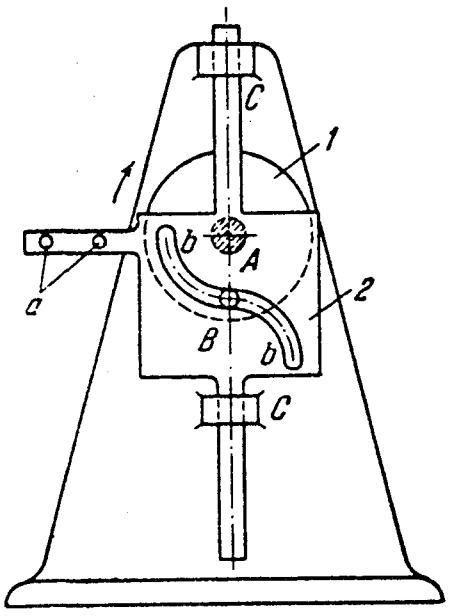
LG
OC




Link *1* of slotted-link mechanism *ABC* rotates about fixed axis *A*. Slotted link *2* is connected by turning pair *B* to link *1* and has slot *b* moving along slider *3* which turns about fixed axis *C*. The axis of slot *b* does not pass through point *B*. Mounted on slotted link *2* is toothed segment *d*. When crank *1* rotates about axis *A*, the tips of claws *a* of segment *d* describe connecting-rod curves in which claws *a* are inserted into perforations of the film, advance the film and are withdrawn from the perforations

## 1389 THREE-BAR SLOTTED-LINK OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA

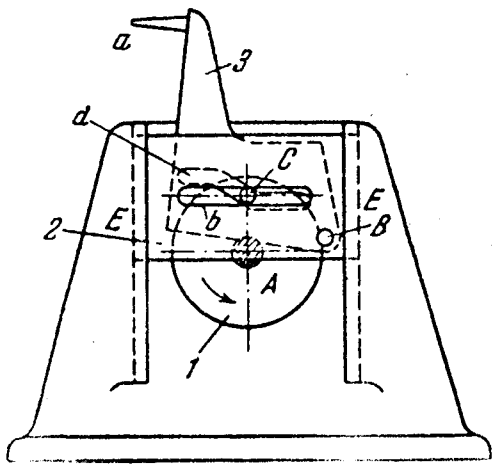
LG
OC




Link *1* of slotted-link mechanism *ABC* rotates about fixed axis *A*. Pin *B* of link *1* slides along slot *b* of link *2* which reciprocates in guides *C-C*. The profile of slot *b* is made up of two quarters of a circle of radius $\overline{AB}$. When link *1* rotates about axis *A*, link *2*, carrying operating claws *a*, reciprocates with two prolonged dwells which occur during the sliding of pin *B*. The dwells correspond to the periods when the centres of the quarter circles of radius $\overline{AB}$ coincide with point *A*.

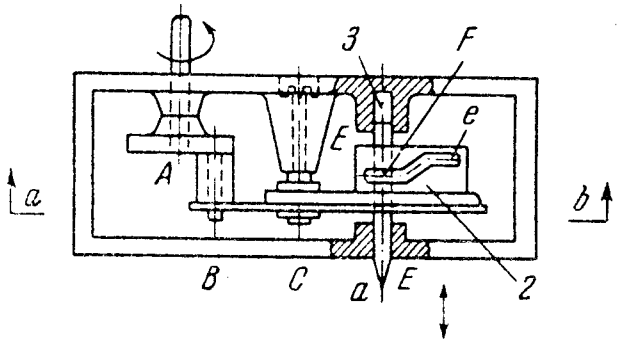
## 1390 FOUR-BAR SLOTTED-LINK OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA

LG
OC

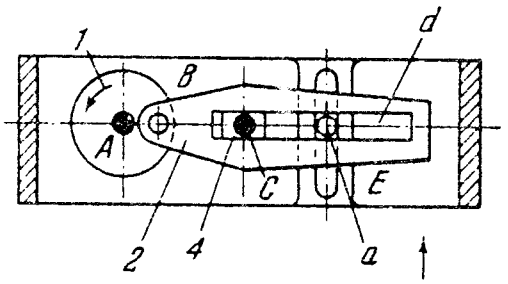



Link *1* of slotted-link mechanism *ACE* rotates about fixed axis *A*. Pin *C* of link *1* slides along straight horizontal slot *b* of link *2* which reciprocates along guides *E*. Link *3* is connected by turning pair *B* to link *2* and has slot *d* along which pin *C* of link *1* slides. When crank *1* rotates about axis *A*, operating claw *a* of link *3* is inserted into a perforation of the film as pin *C* of crank *1* slides along the left half of slot *d* in link *3*. Then the film is advanced by the vertical motion of link *3* together with link *2* and, finally, claw *a* is withdrawn from the perforation as pin *C* slides along the right half of slot *d*.

| 1391 | SPATIAL SLOTTED-LINK OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA | LG OC |
|---|---|---|

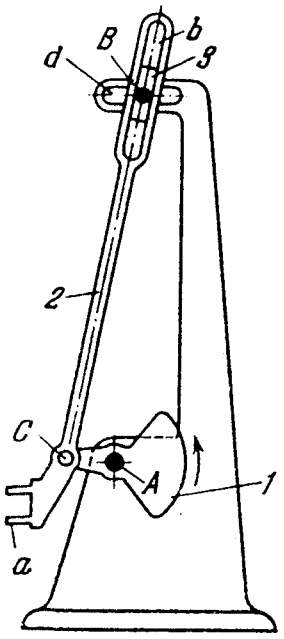



Section a-b



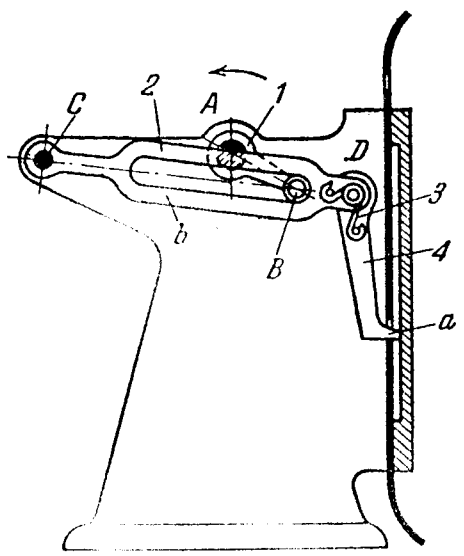

Link *1* of slotted-link mechanism *ABC* rotates about fixed axis *A*. Slotted link *2* is connected by turning pair *B* to link *1* and has slot *d* moving along slider *4* which turns about fixed axis *C*. Link *3* slides in fixed guides *E* and is displaced by slot *d* in the horizontal direction. Link *3* is displaced in the vertical direction by means of slot *e* of slotted link *2* which actuates pin *F* of link *3*. When crank *1* rotates about axis *A*, slotted link *2* displaces link *3* with operating claw *a* in the vertical direction. Pin *F* of link *3*, moving along the left half of slot *e* in link *2*, inserts claw *a* into a perforation of the film. Then the film is advanced by horizontal motion of link *3* from the action of slot *d*. Finally, claw *a* is withdrawn from the perforation as pin *F* slides along the right half of slot *e*.

| 1392 | FOUR-BAR SLOTTED-LINK ADJUSTABLE OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA | LG OC |
|---|---|---|




Link *1* of slotted-link mechanism *ACB* rotates about fixed axis *A*. Slotted link *2* is connected by turning pair *C* to link *1* and has slot *b* which moves along slider *3*. Slider *3* turns about fixed axis *B*. The axis of slot *b* passes through point *C*. When crank *1* rotates about axis *A*, the tips of operating claws *a* on slotted link *2* describe connecting-rod curves in which claws *a* are inserted into perforations of the film, advance the film and are withdrawn from the perforations. The paths of the tips of claws *a* can be changed by adjusting pin *B* along slot *d*.

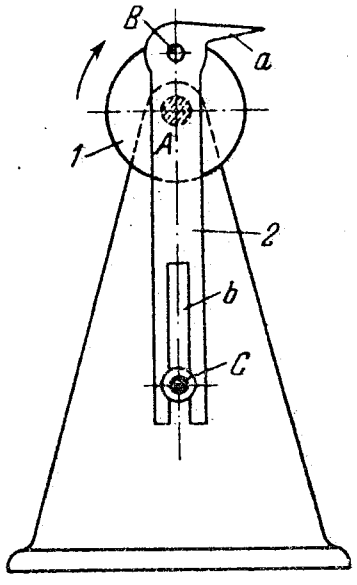
| 1393 | SLOTTED-LINK MOTION PICTURE CAMERA OPERATING CLAW MECHANISM WITH AN ELASTIC LINK | LG OC |
|---|---|---|




Link *1* of slotted-link mechanism *ABC* rotates about fixed axis *A*. Slotted link *2* turns about fixed axis *C* and has slot *b* along which pin *B* of link *1* slides. In the extreme upper position of slotted link *2*, spring *3* inserts claw *a* of link *4* into a perforation of the film. Link *4* is connected by turning pair *D* to link *2*. Upon further rotation of crank *1*, claw *a* advances the film downward. When slotted link *2* starts to move upward from its extreme lower position, claw *a* is withdrawn from the perforation and slides upward along the film.

## 1394 THREE-BAR SLOTTED-LINK OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA

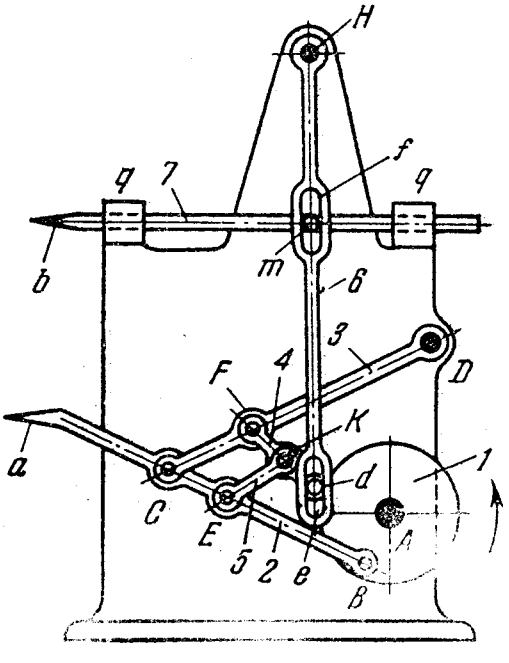
LG
OC




Link *1* of slotted-link mechanism *ABC* rotates about fixed axis *A*. Slotted link *2* is connected by turning pair *B* to link *1* and has slot *b* sliding along fixed pin *C*. The axis of slot *b* passes through point *B*. When link *1* rotates about axis *A*, the tip of claw *a*, mounted on link *2*, describes a connecting-rod curve in which claw *a* is inserted into a perforation of the film, advances the film and is withdrawn from the perforation.

## 1395 SLOTTED-LINK OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA

LG
OC

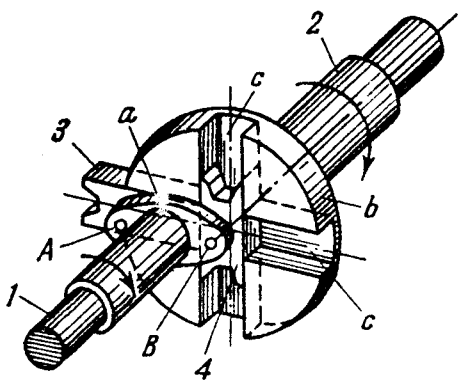



Links *4* and *5* are connected by turning pairs *F* and *E* to rocker arm *3* and connecting rod *2* of four-bar linkage *ABCD*, and by turning pair *K* to each other. Link *4* has pin *d* sliding along slot *e* of link *6* which turns about fixed axis *H*. Slot *f* of link *6* actuates pin *m* of link *7* which slides in fixed guides *q-q*. When crank *1* rotates about fixed axis *A*, claw *a* of connecting rod *2* describes a connecting-rod curve in which claw *a* is inserted into a perforation of the film, advances the film and is withdrawn from the perforation. Claw *b* of link *7* is inserted into a perforation to prevent motion of the film while claw *a* is withdrawn.

# 18. CLUTCH AND COUPLING MECHANISMS (1396 and 1397)

## 1396 LINK-GEAR COUPLING MECHANISM

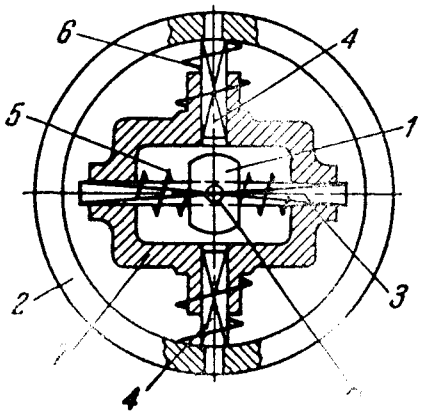
LG C




Cross-member *a* is connected by turning pairs *A* and *B* to sliders *3* and *4*, and is rigidly secured to shaft *1* which rotates in fixed bearings that are not shown. Disk *b* is rigidly secured to shaft *2* and has two diametral slots *c* which are perpendicular to each other. When shaft *1* rotates clockwise, sliders *3* and *4* move along diametral slots *c* of disk *b*, transmitting rotation to shaft *2* in the same direction. The transmission ratio between shafts *1* and *2* is $i_{12} = \frac{\omega_1}{\omega_2} = 2$. Hence, the angle of rotation of link *1* is always twice that of link *2*.

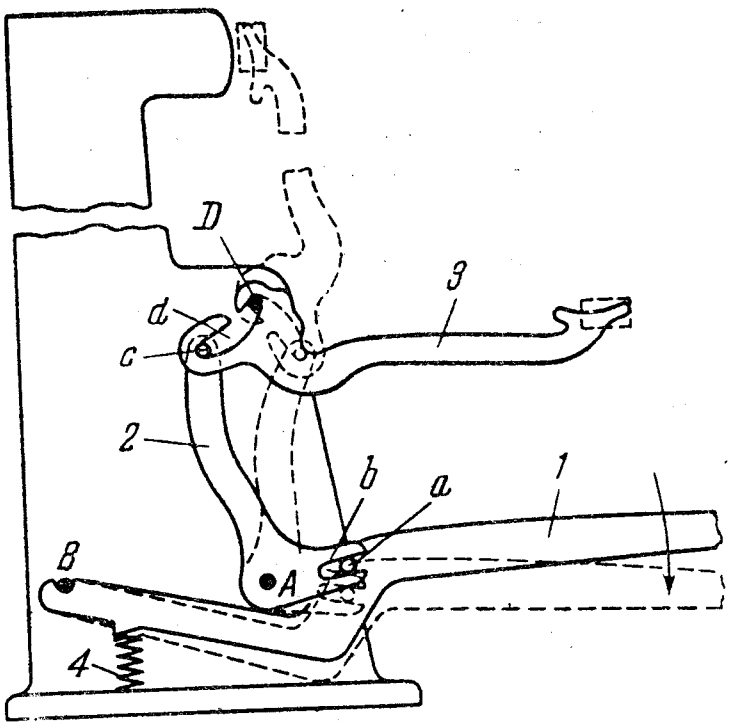
## 1397 SLOTTED-LINK CLUTCH MECHANISM WITH SPRING-LOADED LINKS

LG C




Link *1*, mounted on rod *3*, and rim *2* rotate about fixed axis *A*. Link *1* can slide with rod *3* in cross-head *7* which, in turn, slides freely along spokes *4* of rim *2*. Thus the mechanism permits rotation with a certain eccentricity between the axes of rotation of link *1* and rim *2*. Link *1* is centred by springs *5*

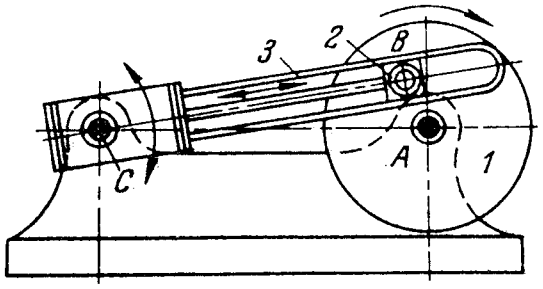
| 1398 | LINK-GEAR TYPEWRITER KEY MECHANISM | LG K |
|---|---|---|




Key *1* turns about fixed axis *B* and has pin *a* which slides along slot *b* of lever *2*. Lever *2* turns about fixed axis *A* and has pin *c* entering slot *d* of link *3* which turns about fixed axis *D*. When key *1* is depressed, bent lever *2*, turning about axis *A*, turns lever *3* to the position shown by dash lines. Spring *4* returns key *1* to the initial position.

# 20. PISTON MACHINE MECHANISMS (1399 through 1413)

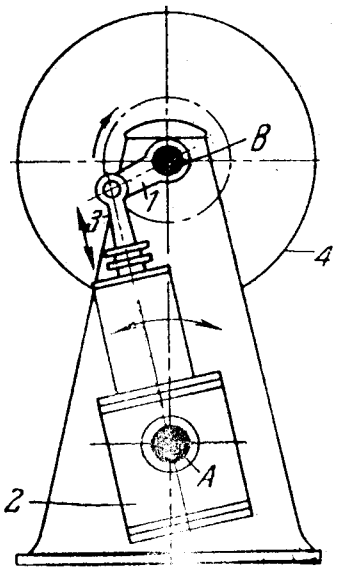
| 1399 | FOUR-BAR SLOTTED-LINK OSCILLATING CYLINDER MECHANISM | LG PM |
|---|---|---|




Disk *1* has a pin connected by turning pair *B* to slider *2*. Slider *2* moves along the slot of slotted member *3* which is secured to a cylinder oscillating about fixed axis *C*. The full angle of oscillation of the cylinder is

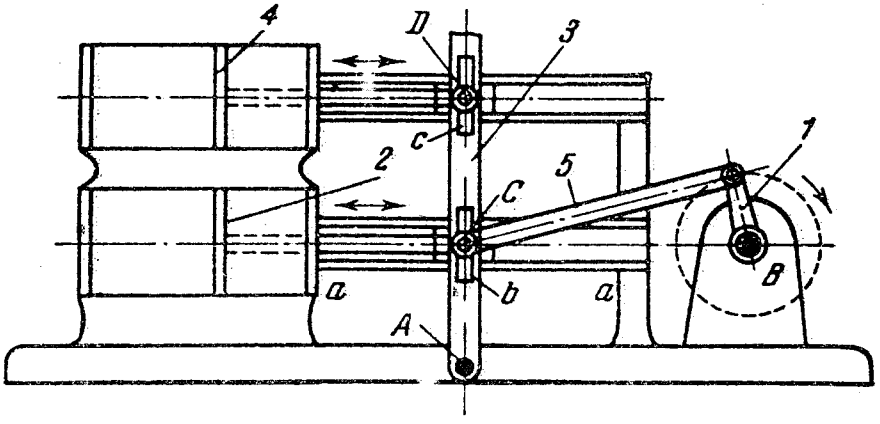
$$\psi = 2 \arcsin \frac{\overline{AB}}{\overline{AC}}.$$

| 1400 | CRANK AND SLOTTED-LINK OSCILLATING CYLINDER MECHANISM | LG PM |
|---|---|---|



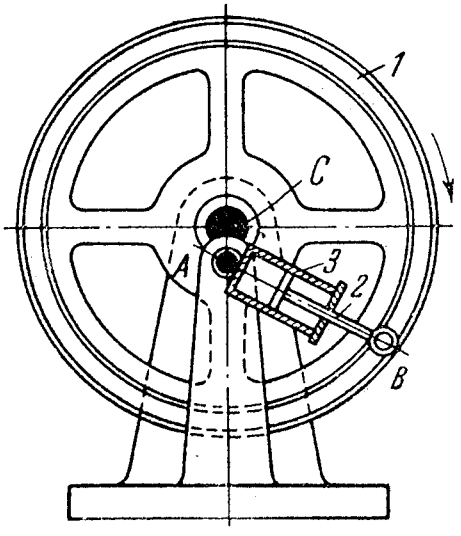

Two-step cylinder *2* oscillates about fixed axis *A*. Two pistons of different diameters are secured rigidly to piston rod *3*. Crank *1* rotates about fixed axis *B* and is rigidly secured to heavy flywheel *4*.

| 1401 | LINK-GEAR MECHANISM OF A TWO-CYLINDER PISTON MACHINE | LG PM |
|---|---|---|




Crank *1* rotates about fixed axis *B* and transmits motion by means of connecting rod *5* to piston *2* whose rod is connected to a slider that moves along fixed guides *a-a*. Slotted link *3* turns about fixed axis *A* and has slots *b* and *c* along which pins *C* and *D* slide. Pins *C* and *D* are secured to the piston rods of pistons *2* and *4*. When crank *1* rotates about axis *B*, slider *2* reciprocates, oscillating slotted link *3* about axis *A*. Link *3* drives piston *4*.

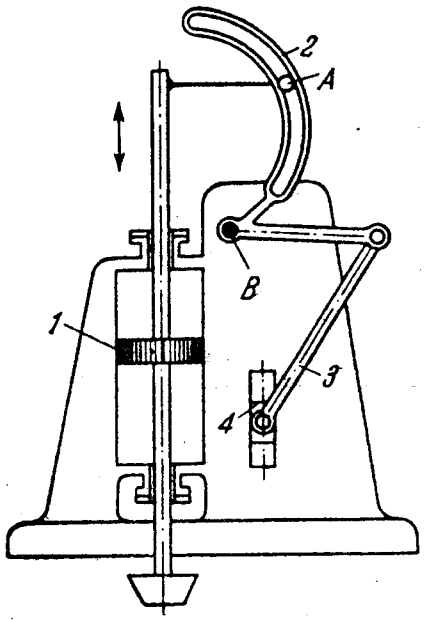
| 1402 | FOUR-BAR SLOTTED-LINK ROTARY CYLINDER MECHANISM | LG PM |
|---|---|---|




Cylinder *3* rotates about fixed axis *A*. Piston rod *2* is connected by turning pair *B* to flywheel *1* which rotates about fixed axis *C*. When flywheel *1* rotates about axis *C*, link *2* reciprocates in cylinder *3*.

## 1403 SLOTTED-LINK MECHANISM OF A PISTON MACHINE

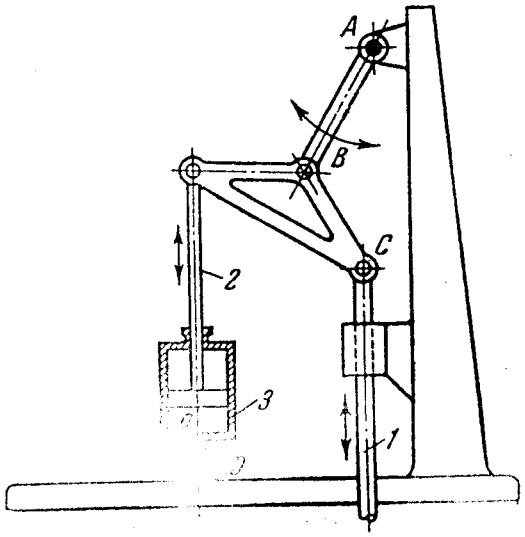
LG PM




Piston *1* reciprocates in a fixed cylinder. Pin *A*, secured to the piston rod, slides along the curvilinear slot of link *2* which oscillates about fixed axis *B*. Connected to link *2* is connecting rod *3* which transmits motion to slide valve *4*.

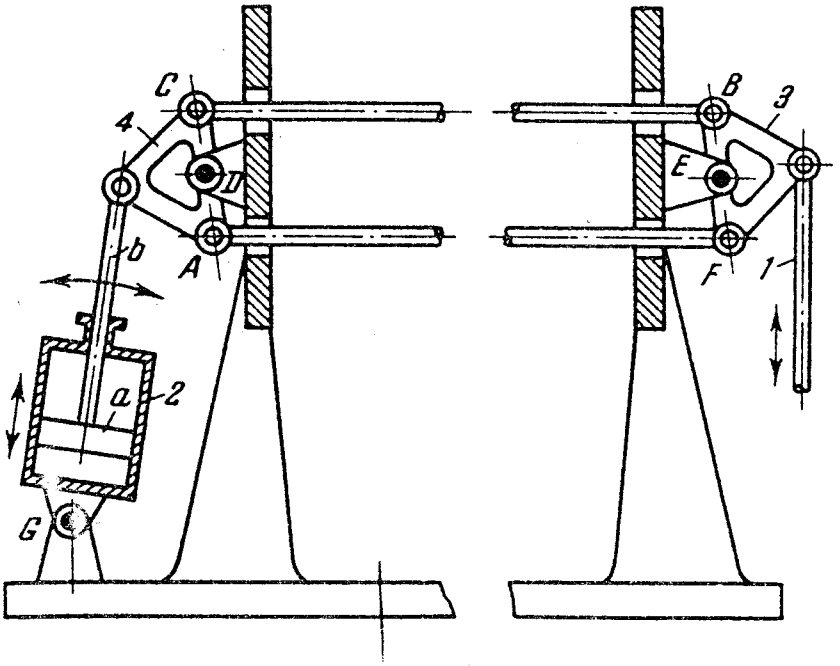
## 1404 LINK-GEAR LEVER-DRIVE OSCILLATING CYLINDER MECHANISM

LG PM



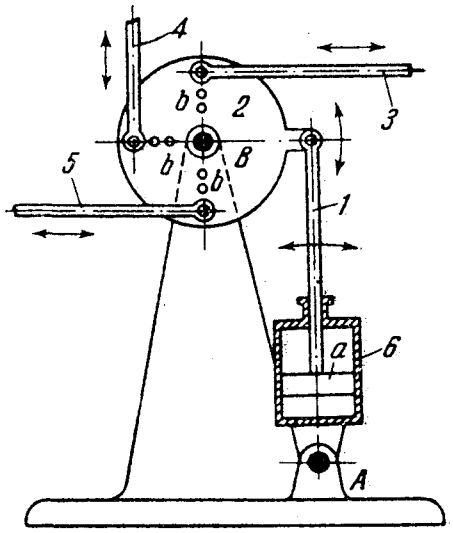

Cylinder *3* oscillates about fixed axis *D*. Piston *a*, reciprocating in cylinder *3*, has rod *2*. The motion of piston rod *2* is reproduced by tie-rod *1* which is the slider of crank-and-slider linkage *ABC*.

| 1405 | LINK-GEAR OSCILLATING CYLINDER MECHANISM WITH A PARALLEL-CRANK LINKAGE | LG PM |
|---|---|---|



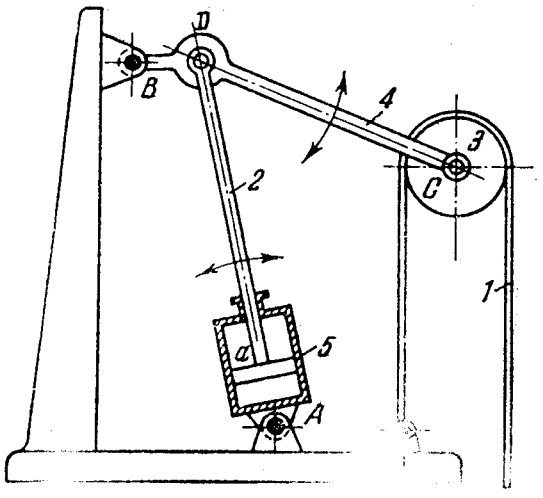

The lengths of the links comply with the conditions: $\overline{AC} = \overline{FB}$, $\overline{CB} = \overline{AF}$ and $\overline{CD} = \overline{DA} = \overline{BE} = \overline{EF}$. Cylinder *2* oscillates about fixed axis *G*. Piston *a*, reciprocating in cylinder *2*, has rod *b*. The motion of piston rod *b* is reproduced by tie-rod *1* by means of parallel-crank linkage *ACBF*. The mechanism can be employed for installations with long distances between axes of rotation *D* and *E* of links *4* and *3*.

## 1406 LINK-GEAR OSCILLATING CYLINDER MECHANISM WITH A DISTRIBUTING DISK — LG PM




Cylinder *6* oscillates about fixed axis *A*. Piston *a*, reciprocating in cylinder *6*, has rod *1*. Motion is transmitted from rod *1* to distributing disk *2* which transmits motion to tie-rods *3*, *4* and *5*. To obtain different kinds of motion of tie-rods *3*, *4* and *5*, disk *2* has series of holes *b* for setting the tie-rods at various distances from fixed axis *B* of rotation.

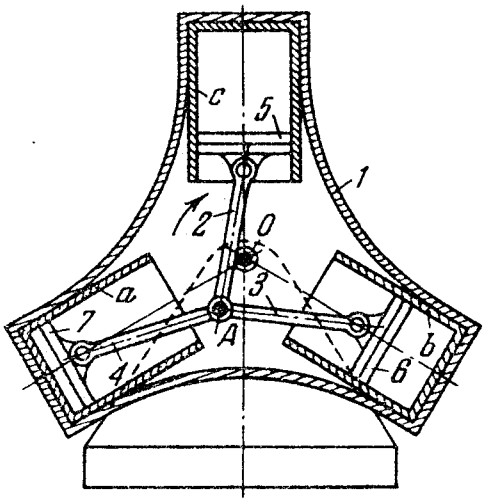
## 1407 LINK-GEAR OSCILLATING CYLINDER MECHANISM WITH A FLEXIBLE DRIVE — LG PM




Cylinder *5* oscillates about fixed axis *A*. Piston *a*, reciprocating in cylinder *5*, has rod *2* which is connected by turning pair *D* to link *4*. Link *4* has the form of a bent lever and turns about fixed axis *B*. Pulley *3* is connected by turning pair *C* to link *4*. The motion of piston rod *2* is reproduced by flexible link *1* which runs over pulley *3*.

## 1408 LINK-GEAR ROTARY CYLINDER PISTON MACHINE MECHANISM

LG PM

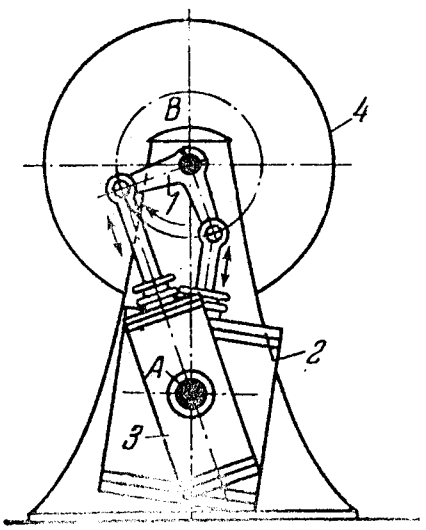



Cylinder block with cylinders *a*, *b* and *c* rotates about fixed axis *O*. Connecting rods *2*, *3* and *4* rotate about fixed axis *A* and transmit reciprocating motion to pistons *5*, *6* and *7* with respect to the cylinder axes. The full stroke of the pistons with respect to the cylinders equals

$$s = 2\overline{OA}.$$

## 1409 CRANK AND SLOTTED-LINK DOUBLE OSCILLATING CYLINDER MECHANISM

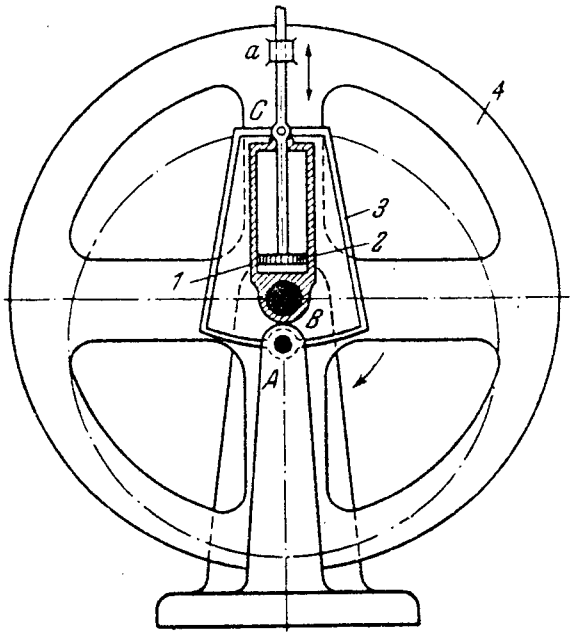
LG PM




Cylinders *2* and *3* oscillate about common fixed axis *A*. Cranks *1* rotate about fixed axis *B* and are rigidly secured to heavy flywheel *4*. Different kinds of motion of the pistons in their cylinders can be obtained by varying the lengths of cranks *1* and the angle between them.

## 1410 FOUR-BAR SLOTTED-LINK ROTARY CYLINDER MECHANISM

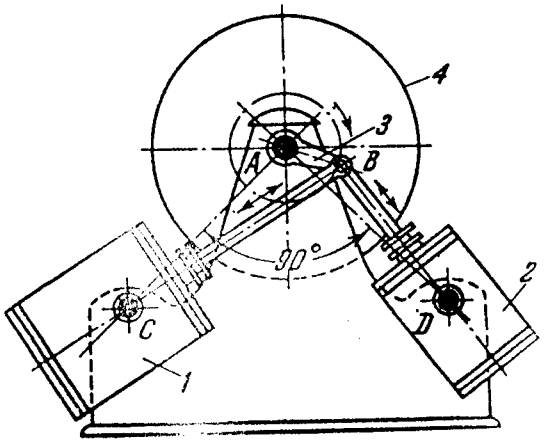
LG PM




Cylinder *1* is rigidly mounted on flywheel *4* which rotates about fixed axis *B*. When flywheel *4* rotates about axis *B*, the rod of piston *2* reciprocates in guide *a* on the rim of the flywheel. The piston rod is connected by turning pair *C* to frame *3* which rotates about fixed axis *A*.

## 1411 CRANK AND SLOTTED-LINK MECHANISM WITH TWO OSCILLATING CYLINDERS

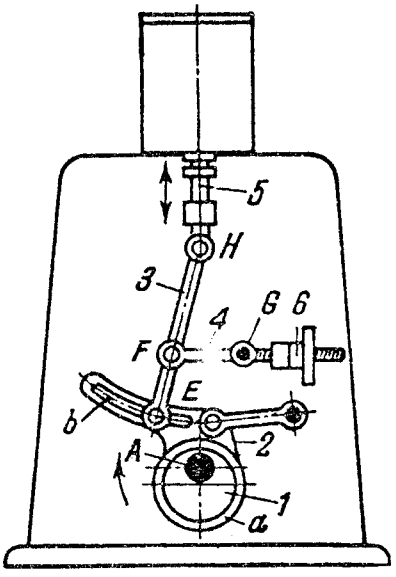
LG PM




Cylinders *1* and *2* oscillate about fixed axes *C* and *D*. The axes of the cylinders always pass through point *B* of crank *3* which rotates about fixed axis *A*. Angle *CAD* equals 90°. Rigidly secured to crank *3* is heavy flywheel *4* which rotates about axis *A*.

## 1412 LINK-GEAR ADJUSTABLE-STROKE PISTON MACHINE MECHANISM

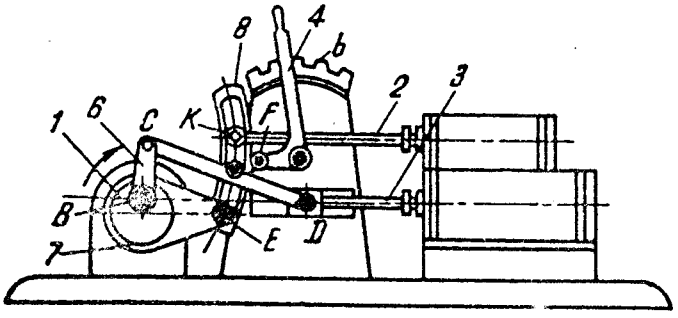
LG PM




Eccentric *1* rotates about fixed axis *A*. Connecting rod *2* has collar *a* encircling eccentric *1* and slot *b* along which pin *E* of link *3* slides. Link *3* is connected by turning pairs *F* and *H* to link *4* and piston rod *5*. Link *4* turns about fixed axis *G*. When eccentric *1* rotates about axis *A*, piston rod *5* reciprocates. The stroke of piston rod *5* can be varied by means of screw device *6* which adjusts the position of point *G* of link *4*.

## 1413 LINK-GEAR PISTON MACHINE MECHANISM WITH STROKE ADJUSTMENT OF ONE PISTON

LG PM

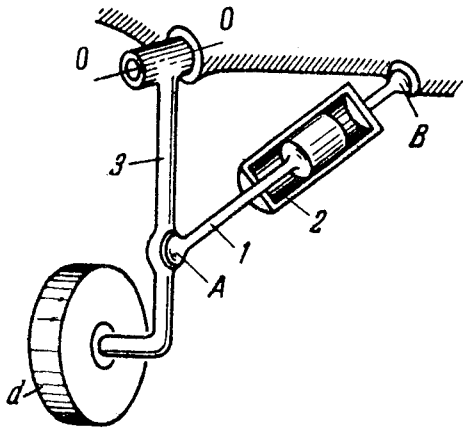



Piston *3* is driven by crank-and-slider linkage *BCD*. Rigidly secured to crank *6* is eccentric *1*, both rotating about fixed axis *B*. Link *7* has a collar encircling eccentric *1*. Link *7* is connected by turning pair *E* to slotted link *8* which oscillates about fixed axis *F*. Pin *K* of piston rod *2* slides along the slot of link *8*. When eccentric *1* and crank *6* rotate about axis *B*, pistons *2* and *3* reciprocate in their cylinders. The stroke of piston *2* can be varied by setting lever *4* and locking it as required on quadrant *b*.

# 21. AIRCRAFT LANDING GEAR MECHANISMS (1414 through 1443)

## 1414 SPATIAL SLIDING-LINK MECHANISM OF RETRACTABLE AIRCRAFT LANDING GEAR

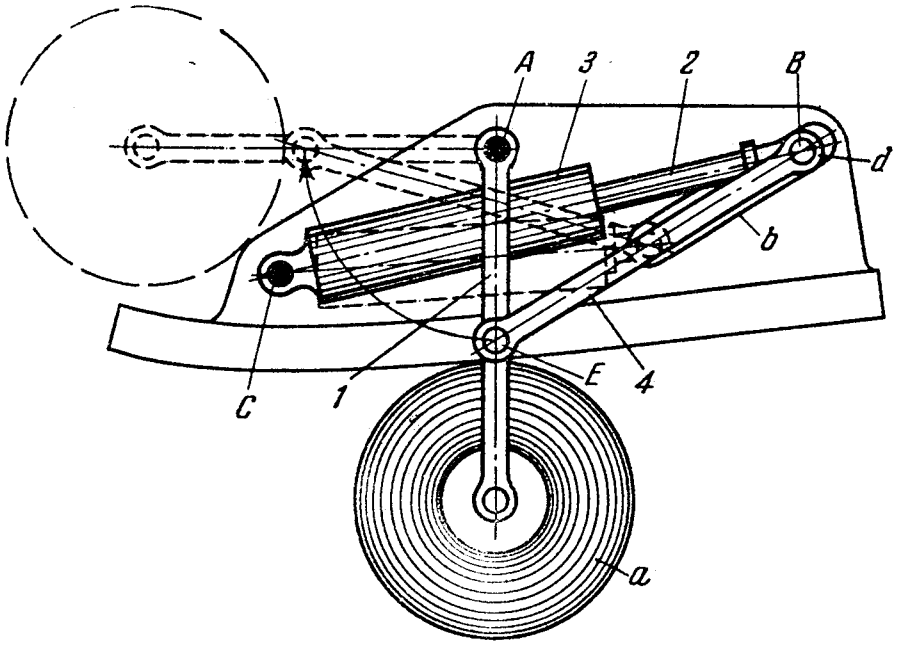
LG AL




Link *3* with wheel *d* turns about fixed axis *O-O* of a frame member of the aircraft. Link *1* is connected by spherical pair *A* to link *3* and by a sliding pair to link *2* which, in turn, is connected by spherical pair *B* to the frame member. When piston *1* moves into cylinder *2*, link *3* is turned about axis *O-O* to retract the landing gear.

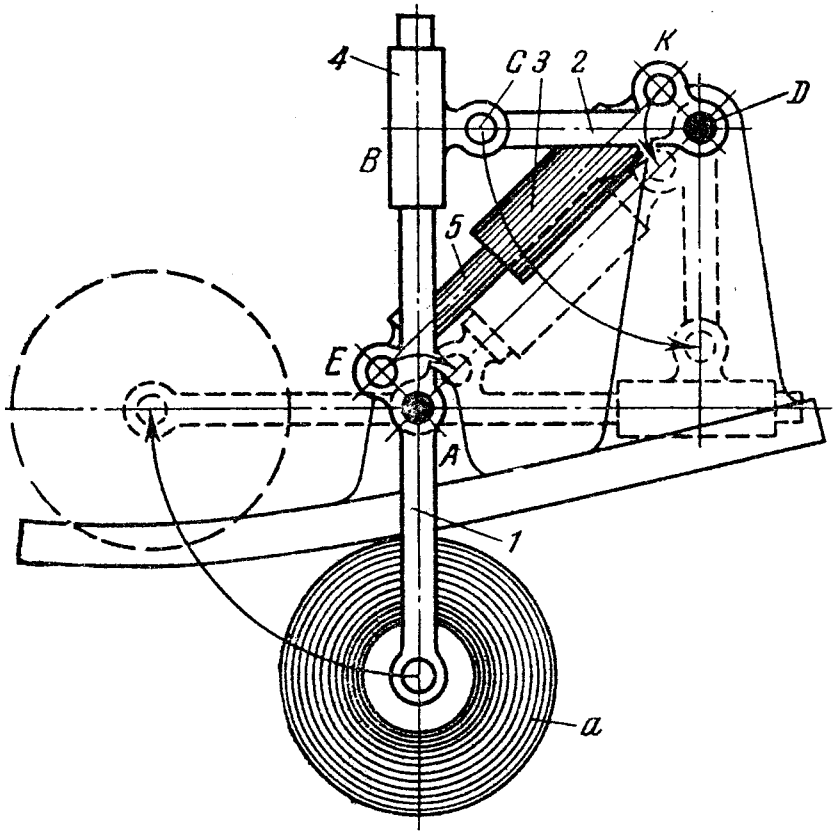
## 1415 LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM

LG AL



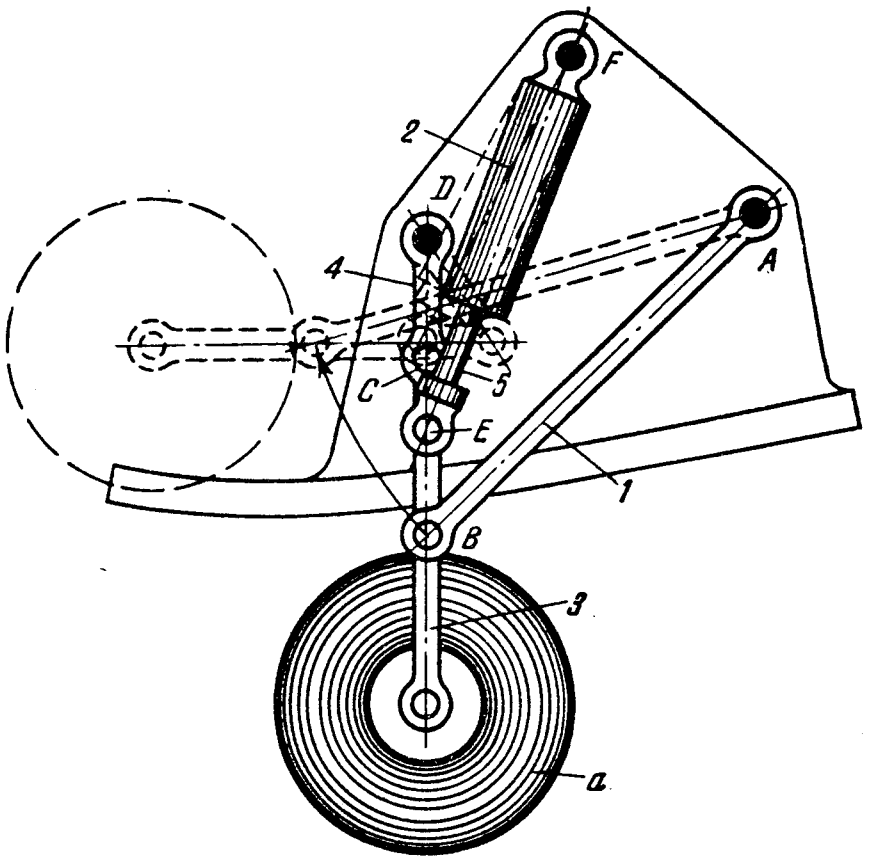

Link *1* with wheel *a* turns about fixed axis *A* of the aircraft frame member. Connecting rod *4* is connected by turning pair *E* to link *1* and its end *d* slides along fixed guide link *4* is actuated by piston rod *2* of cylinder *3* and is connected by turning pair *B* to the rod. Cylinder *3* turns about fixed axis *C* of the aircraft frame. When piston rod *2* moves into cylinder *3*, link *1* is turned clockwise, and the landing gear is retracted as shown by the dash lines.

| 1416 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|



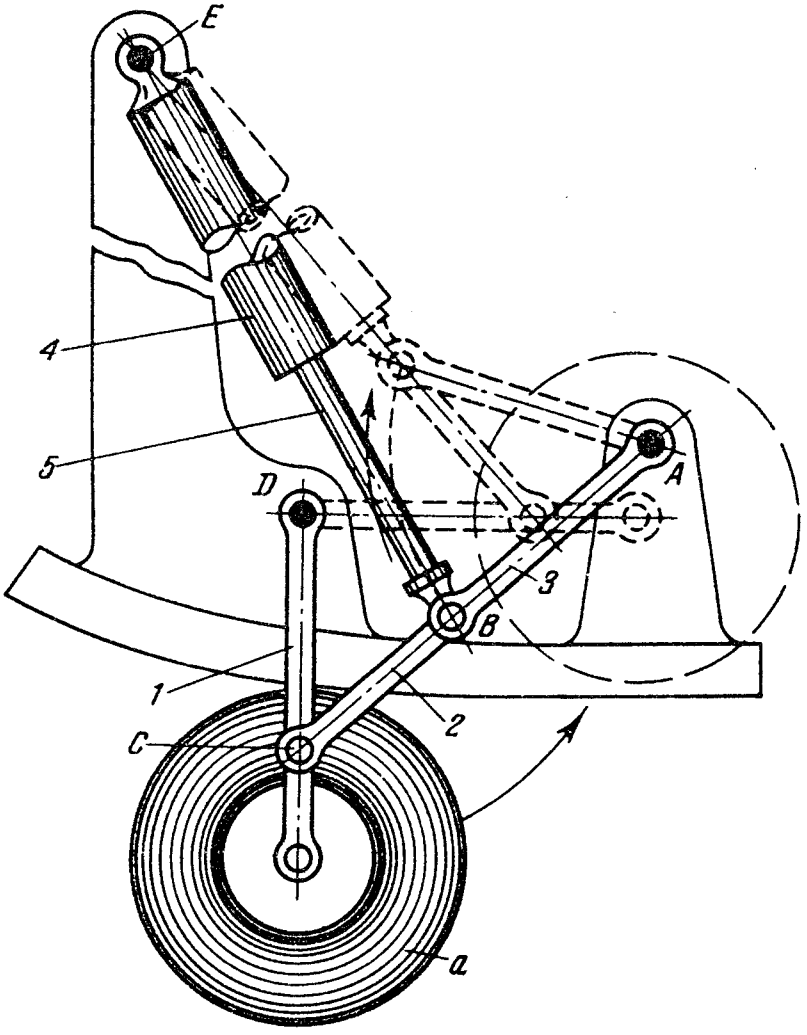

Link *1* with wheel *a* turns about fixed axis *A* of the aircraft frame member and is connected by sliding pair *B* to link *4*. Link *4* is connected by turning pair *C* to link *2* which turns about fixed axis *D* of the aircraft frame. Piston rod *5* of retracting cylinder *3* is connected by turning pair *F* to link *1*. Cylinder *3* is connected by turning pair *K* to link *2*. When piston rod *5* moves into retracting cylinder *3*, link *1* is turned clockwise, and the landing gear is retracted as shown by the dash lines.

| 1417 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|

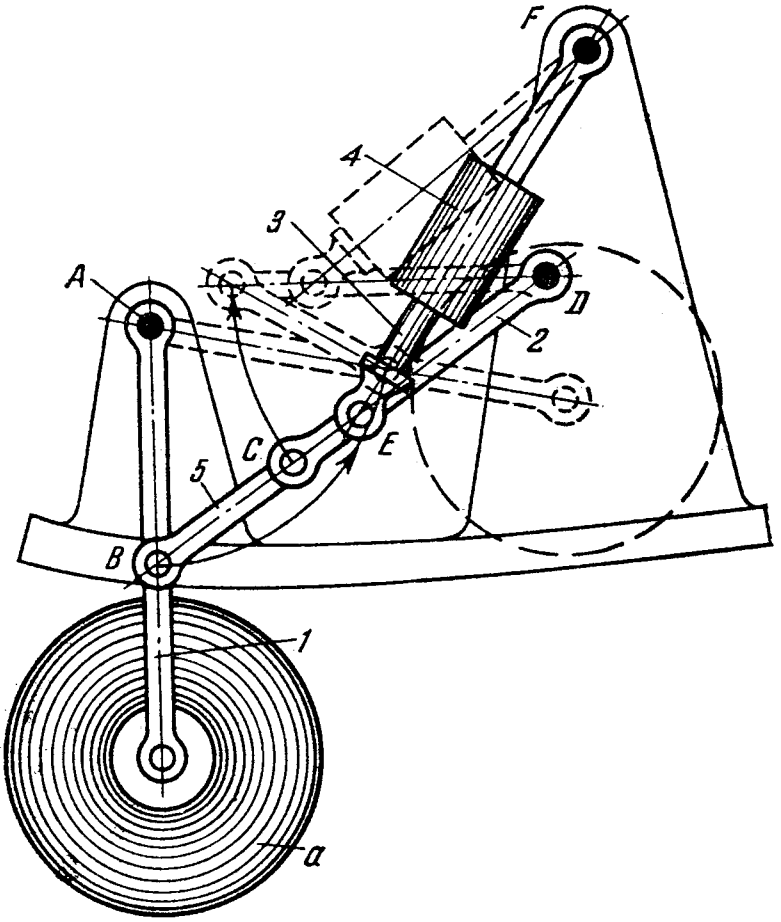



Link *1* turns about fixed axis *A* of the aircraft frame member and is connected by turning pair *B* to link *3* which mounts landing wheel *a*. Link *3* is connected by turning pair *C* to link *4* which turns about fixed axis *D* of the aircraft frame. Piston rod *5* of retracting cylinder *2* is connected by turning pair *E* to link *3*. Cylinder *2* turns about fixed axis *F* of the aircraft frame. When piston rod *5* moves into retracting cylinder *2*, link *1* is turned clockwise, and the landing gear is retracted as shown by the dash lines.

| 1418 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|

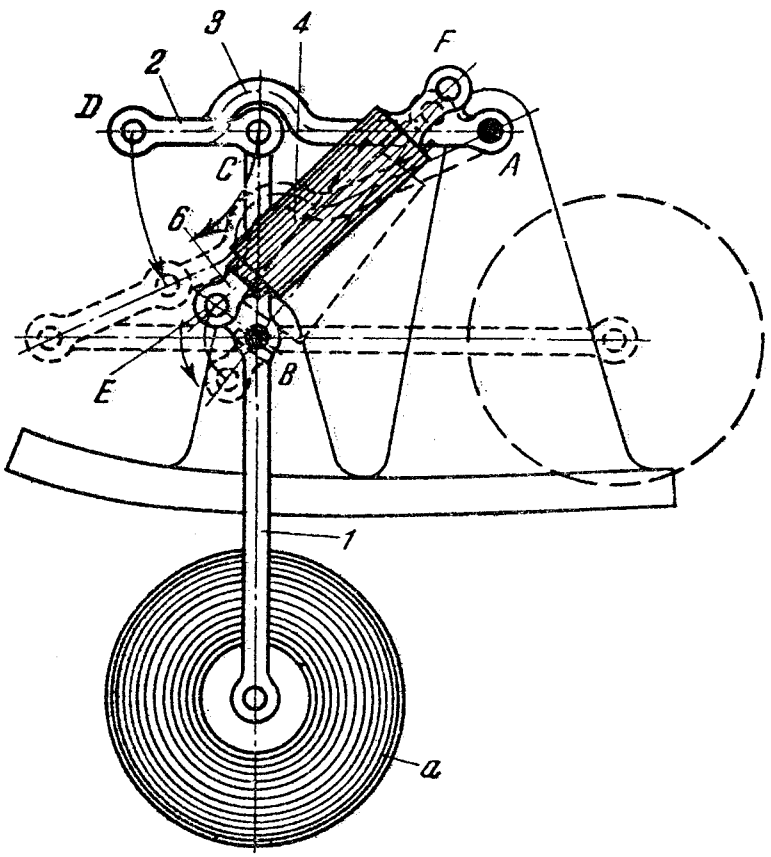



Link *3* turns about fixed axis *A* of the aircraft frame member and is connected by turning pair *B* to link *2*. Link *2* is connected by turning pair *C* to link *1* which turns about fixed axis *D* of the aircraft frame and mounts landing wheel *a*. Piston rod *5* of retracting cylinder *4* is connected by turning pairs *B* to links *2* and *3*. Cylinder *4* turns about fixed axis *E* of the aircraft frame. When piston rod *5* moves into retracting cylinder *4*, link *1* is turned counterclockwise, and the landing gear is retracted as shown by the dash lines.



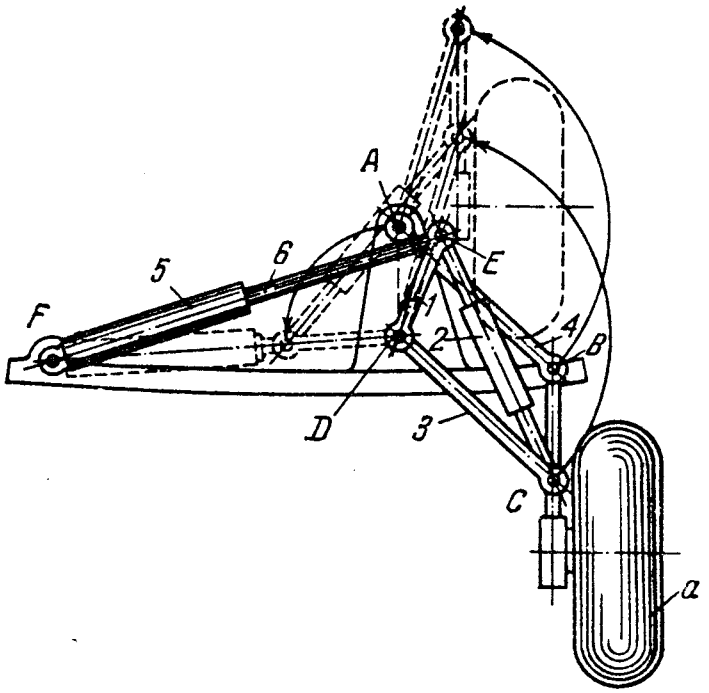

Link *1* with wheel *a* turns about fixed axis *A* of the aircraft frame member. Link *5* is connected by turning pairs *B* and *C* to links *1* and *2*. Link *2* turns about fixed axis *D* of the aircraft frame. Piston rod *3* of retracting cylinder *4* is connected by turning pair *E* to link *2*. Cylinder *4* turns about fixed axis *F* of the aircraft frame. When piston rod *3* moves into retracting cylinder *4*, link *1* is turned counterclockwise and link *2* clockwise, and the landing gear is retracted as shown by the dash lines.

| 1420 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|



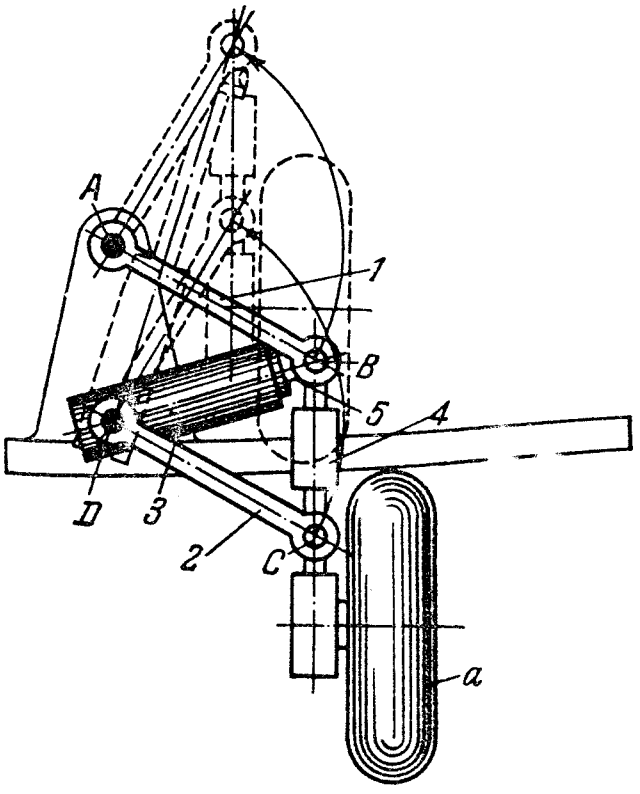

Link *1* with wheel *a* turns about fixed axis *B* of the aircraft frame member. Link *2* is connected by turning pairs *C* and *D* to link *1* and to link *3* which turns about fixed axis *A* of the aircraft frame. Piston rod *6* of retracting cylinder *4* is connected by turning pair *E* to link *1*. Cylinder *4* is connected by turning pair *F* to link *3*. When piston rod *6* moves out of retracting cylinder *4*, links *1* and *3* are turned counterclockwise, and the landing gear is retracted as shown by the dash lines.

| 1421 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$ and $\overline{AD} = \overline{BC}$. Thus, figure $ABCD$ is a parallel-crank linkage whose connecting rod $BC$ mounts landing wheel $a$. Links *1* and *3* turn about fixed axis $D$ of the aircraft frame member. Oil shock absorber *2* is mounted between points $E$ and $C$. Hence, the whole system $EDC$ turns about common axis $D$. Retracting cylinder *5* turns about fixed axis $F$ of the aircraft frame and its piston rod *6* is connected by turning pair $E$ to system $EDC$. When piston rod *6* moves into retracting cylinder *5*, links *1*, *3* and *4* are turned counterclockwise, and the landing gear is retracted as shown by the dash lines.

| 1422 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$ and $\overline{AD} = \overline{BC}$. Thus, figure *ABCD* is a parallel-crank linkage whose connecting rod *BC* mounts landing wheel *a*. Piston rod *5* of retracting cylinder *3* is connected by turning pairs *B* to links *1* and *4*. Cylinder *3* and link *1* turn about fixed axes *D* and *A* of the aircraft frame. When piston rod *5* moves out of cylinder *3*, links *1* and *2* are turned counterclockwise, and the landing gear is retracted as shown by the dash lines.

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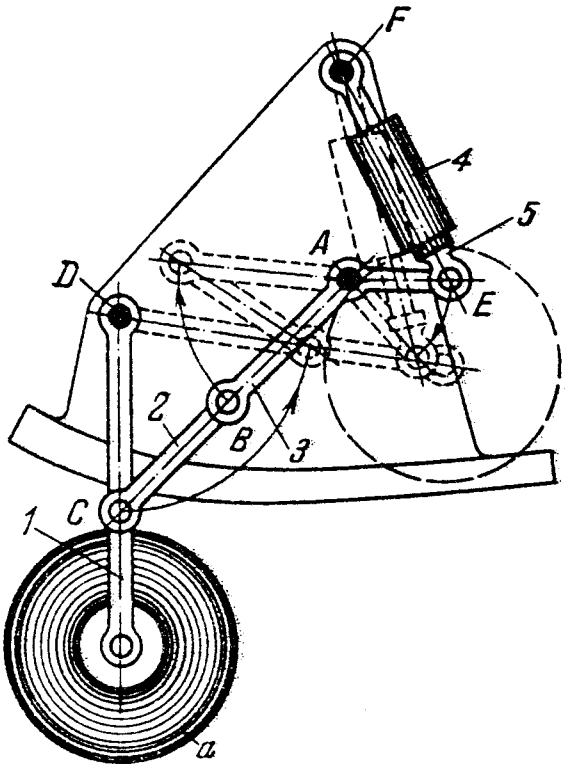
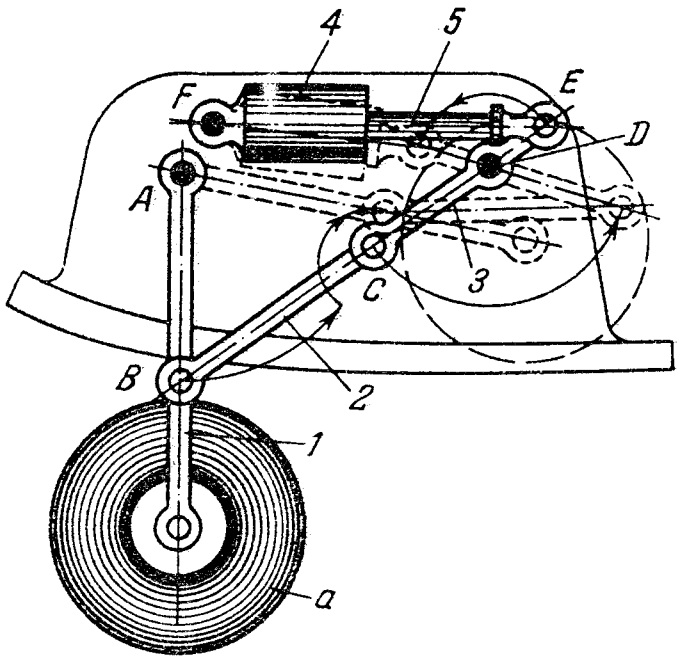
## LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM

LG AL



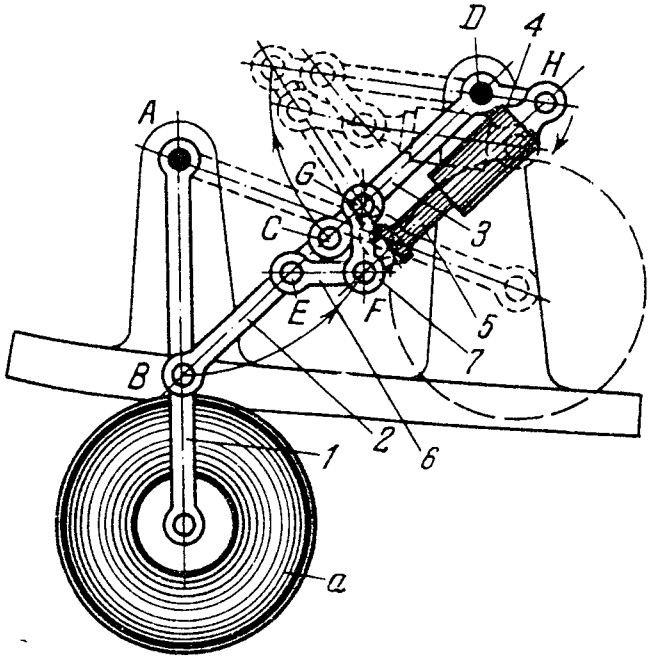

Link *1* with wheel *a* turns about fixed axis *D* of the aircraft frame member. Link *2* is connected by turning pairs *C* and *B* to links *1* and *3*. Link *3* turns about fixed axis *A* of the aircraft frame. Piston rod *5* of retracting cylinder *4* is connected by turning pair *E* to link *3*. Cylinder *4* turns about fixed axis *F* of the aircraft frame. When piston rod *5* moves out of retracting cylinder *4*, link *1* is turned counterclockwise and link *3* clockwise, and the landing gear is retracted as shown by the dash lines.

| 1424 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|



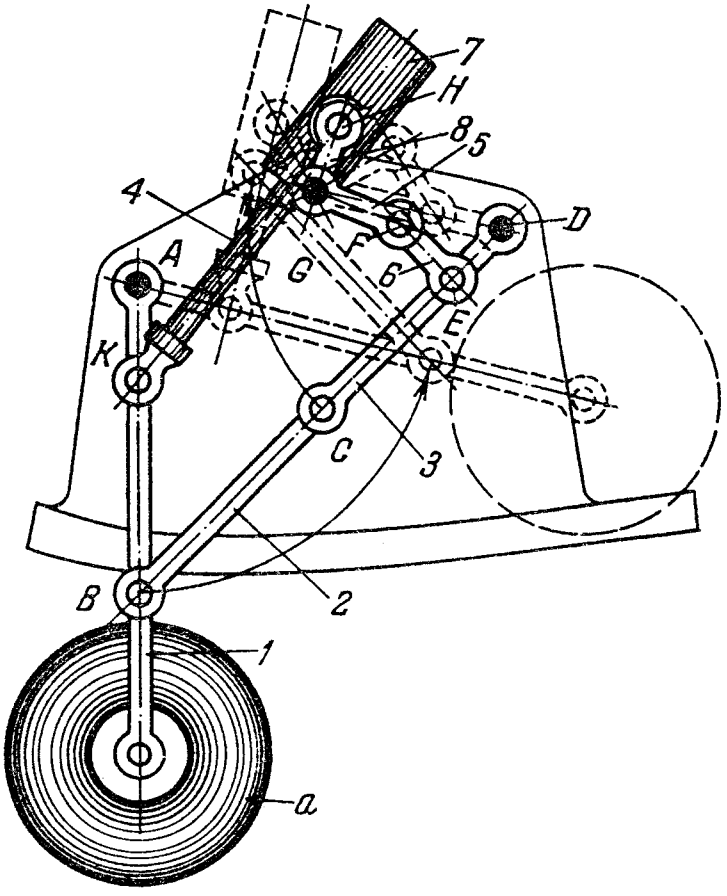

Link *1* with wheel *a* turns about fixed axis *A* of the aircraft frame member. Link *2* is connected by turning pairs *B* and *C* to links *1* and *3*. Link *3* turns about fixed axis *D* of the aircraft frame. Piston rod *5* of retracting cylinder *4* is connected by turning pair *E* to link *3*. Cylinder *4* turns about fixed axis *F* of the aircraft frame. When piston rod *5* moves into retracting cylinder *4*, links *1* and *3* are turned counterclockwise, and the landing gear is retracted as shown by the dash lines.

| 1425 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|



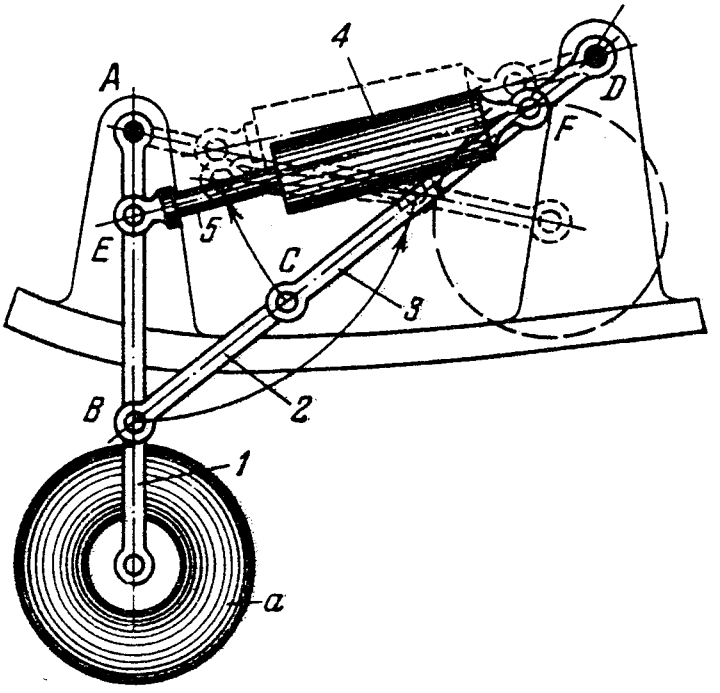

Link *1* with wheel *a* turns about fixed axis *A* of the aircraft frame member. Link *2* is connected by turning pairs *B* and *C* to links *1* and *3*. Link *3* turns about fixed axis *D* of the aircraft frame. Links *6* and *7* are of equal length; they are connected together by turning pair *F* and to links *2* and *3* by turning pairs *E* and *G*. Piston rod *5* of retracting cylinder *4* is connected by turning pairs *F* to links *6* and *7*. Cylinder *4* is connected by turning pair *H* to link *3*. When piston rod *5* moves into retracting cylinder *4*, link *1* is turned counterclockwise and link *3* clockwise, and the landing gear is retracted as shown by the dash lines.

| 1426 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|



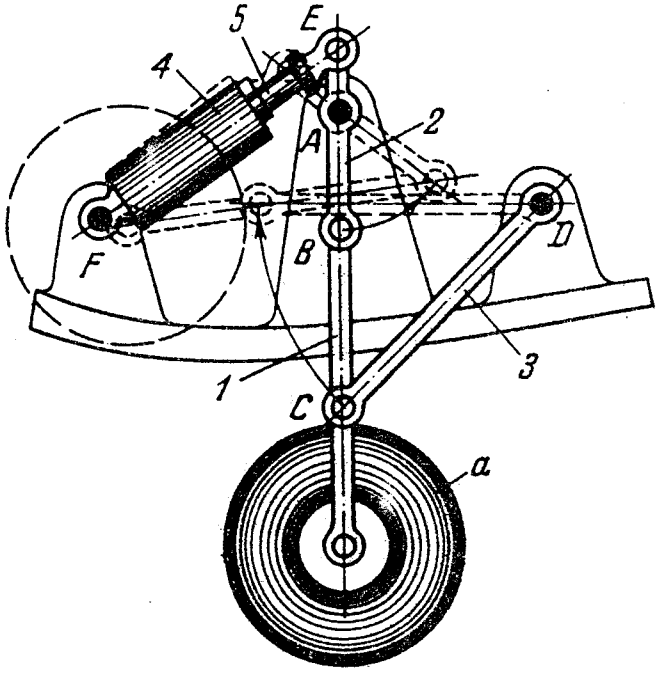

Link *1* with wheel *a* turns about fixed axis *A* of the aircraft frame member. Link *2* is connected by turning pairs *B* and *C* to links *1* and *3*. Link *3* turns about fixed axis *D* of the aircraft frame. Link *6* is connected by turning pairs *E* and *F* to link *3* and to link *5* which turns about fixed axis *G* of the aircraft frame. Piston rod *4* of retracting cylinder *7* is connected by turning pair *K* to link *1*. Cylinder *7* is connected by turning pair *H* to link *8*. When piston rod *4* moves into retracting cylinder *7*, link *1* is turned counterclockwise and link *3* clockwise, and the landing gear is retracted as shown by the dash lines.

| 1427 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|



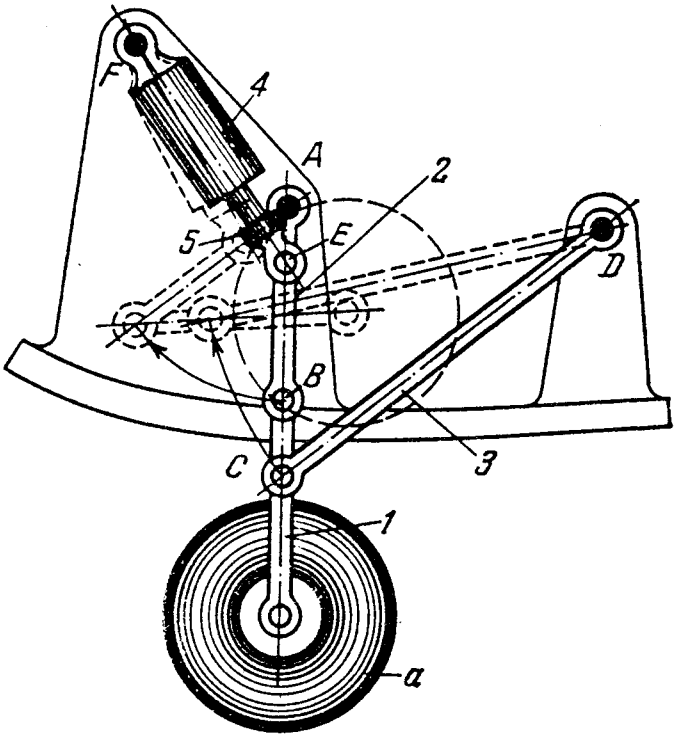

Link *1* with wheel *a* turns about fixed axis *A* of the aircraft frame member. Link *2* is connected by turning pairs *B* and *C* to links *1* and *3*. Link *3* turns about fixed axis *D* of the aircraft frame. Piston rod *5* of retracting cylinder *4* is connected by turning pair *E* to link *1*. Cylinder *4* is connected by turning pair *F* to link *3*. When piston rod *5* moves into retracting cylinder *4*, link *1* is turned counterclockwise and link *3* clockwise, and the landing gear is retracted as shown by the dash lines.

| 1428 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|



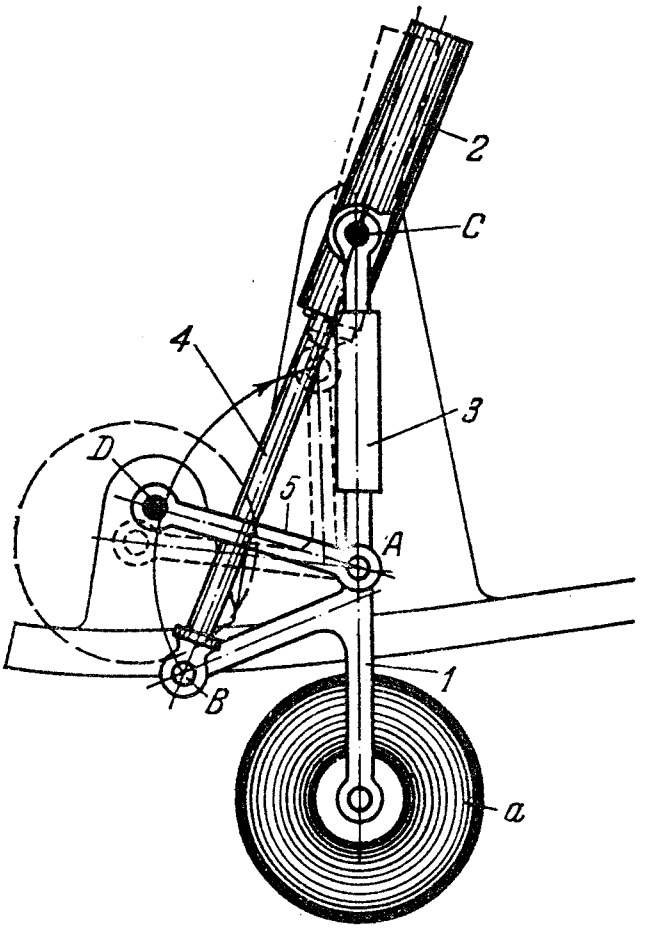

Link *2* turns about fixed axis *A* of the aircraft frame member. Link *1* with wheel *a* is connected by turning pairs *B* and *C* to links *2* and *3*. Link *3* turns about fixed axis *D* of the aircraft frame. Piston rod *5* of retracting cylinder *4* is connected by turning pair *E* to link *2*. Cylinder *4* turns about fixed axis *F* of the aircraft frame. When piston rod *5* moves into retracting cylinder *4*, link *3* is turned clockwise and link *2* counterclockwise, and the landing gear is retracted as shown by the dash lines.

| 1429 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|

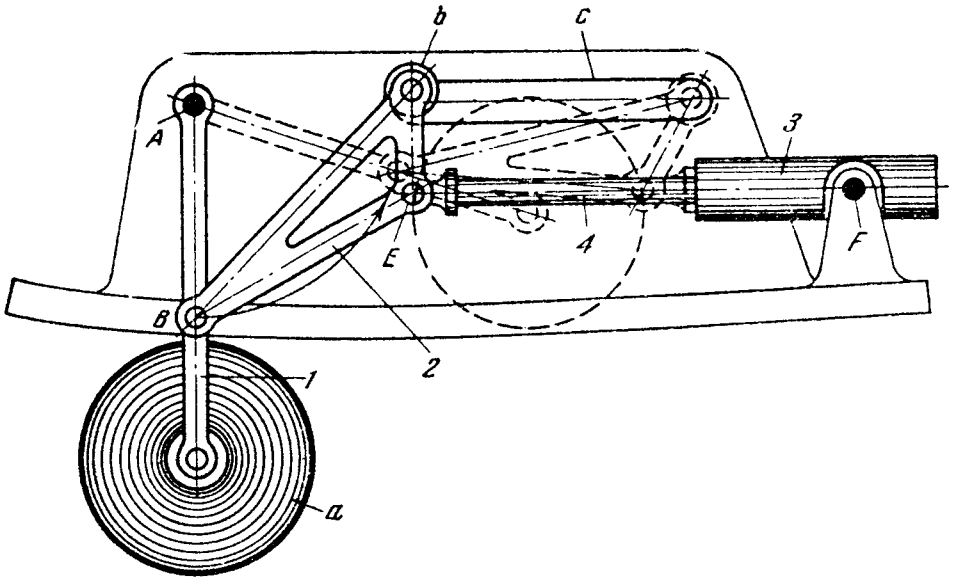



Link *2* turns about fixed axis *A* of the aircraft frame member. Link *1* with wheel *a* is connected by turning pairs *B* and *C* to links *2* and *3*. Link *3* turns about fixed axis *D* of the aircraft frame. Piston rod *5* of retracting cylinder *4* is connected by turning pair *E* to link *2*. Cylinder *4* turns about fixed axis *F* of the aircraft frame. When piston rod *5* moves into retracting cylinder *4*, links *2* and *3* are turned clockwise, and the landing gear is retracted as shown by the dash lines.

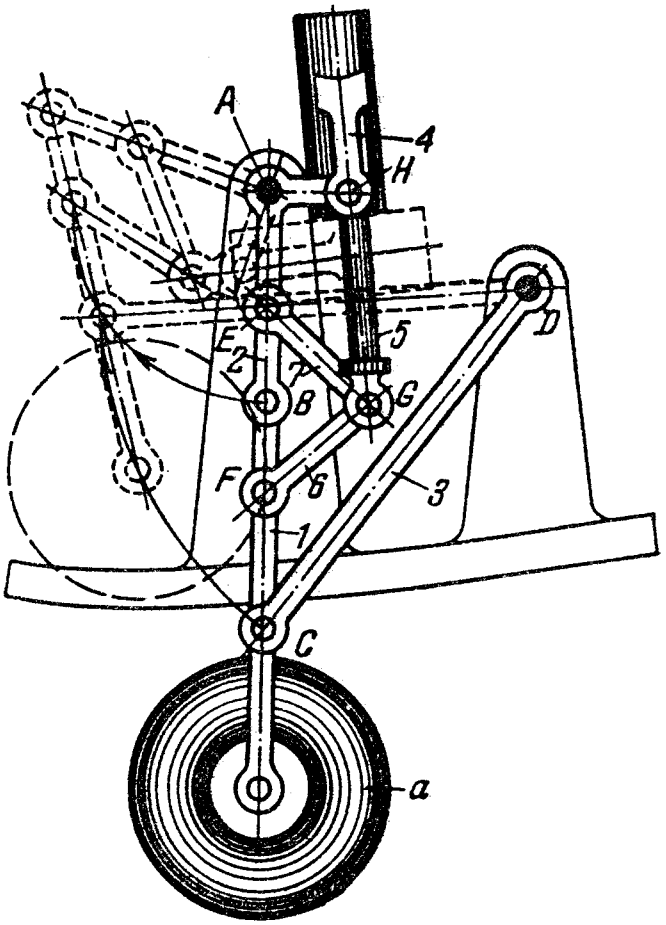
| 1430 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|




Link *5* turns about fixed axis *D* of the aircraft frame member. Link *1* with wheel *a* is connected by turning pair *A* to link *5*. Piston rod *4* of retracting cylinder *2* is connected by turning pair *B* to link *1*. Cylinder *2* turns about fixed axis *C* of the aircraft frame. When piston rod *4* moves into retracting cylinder *2*, link *1* is turned clockwise about axis *A*, and the landing gear is retracted as shown by the dash lines. Shock absorber *3* is mounted between points *A* and *C*.

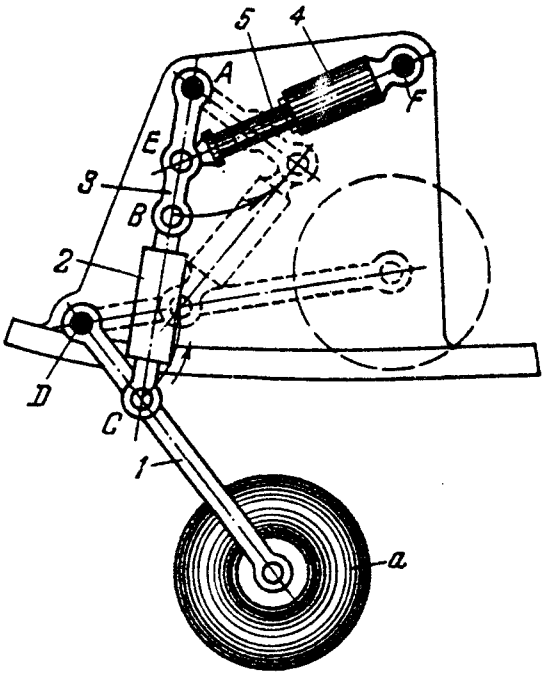



Link *1* with wheel *a* turns about fixed axis *A* of the aircraft frame member. Link *2* is connected by turning pairs *B* and *E* to link *1* and piston rod *4* of retracting cylinder *3*. Cylinder *3* turns about fixed axis *F* of the aircraft frame. Link *2* has roller *b* which slides freely along slot *c* of the aircraft frame. When piston rod *4* moves into retracting cylinder *3*, link *1* is turned counterclockwise, and the landing gear is retracted as shown by the dash lines. When the landing gear is lowered, roller *b* of link *2* enters a notch of slot *c* so that link *2* serves as a brace for link *1*. This relieves the load on cylinder *3*. When the landing gear is retracted, roller *b* automatically comes out of the notch and slides along slot *c*.



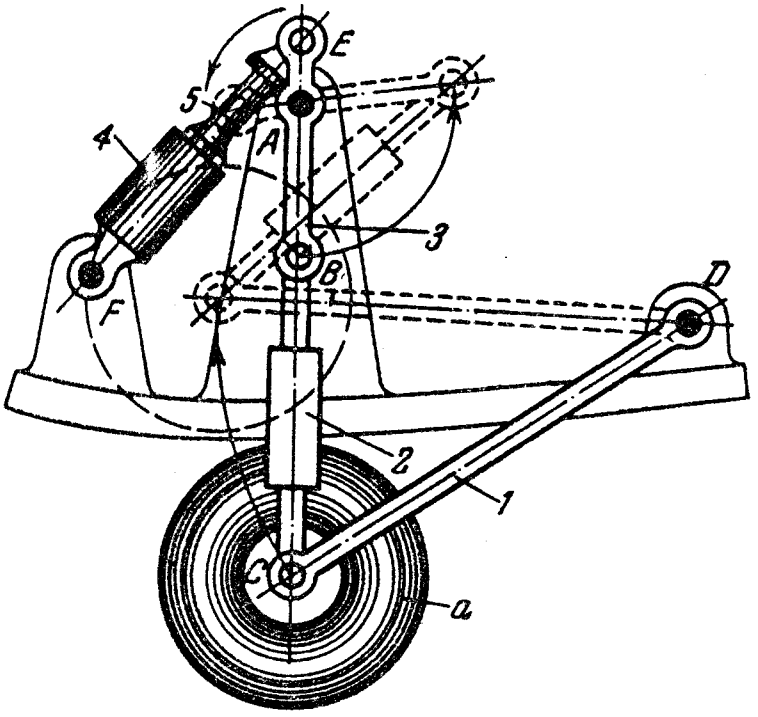

Link *2* turns about fixed axis *A* of the aircraft frame member. Link *1* with wheel *a* is connected by turning pairs *B* and *C* to links *2* and *3*. Link *3* turns about fixed axis *D* of the aircraft frame. Links *6* and *7* are of equal length; they are connected together by turning pair *G*, and by turning pairs *F* and *E* to links *1* and *2*. Piston rod *5* of retracting cylinder *4* is connected by turning pairs *G* to links *6* and *7*. Cylinder *4* is connected by turning pair *H* to link *2*. When piston rod *5* moves into retracting cylinder *4*, links *2* and *3* turn clockwise, and the landing gear is retracted as shown by the dash lines.

| 1433 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|



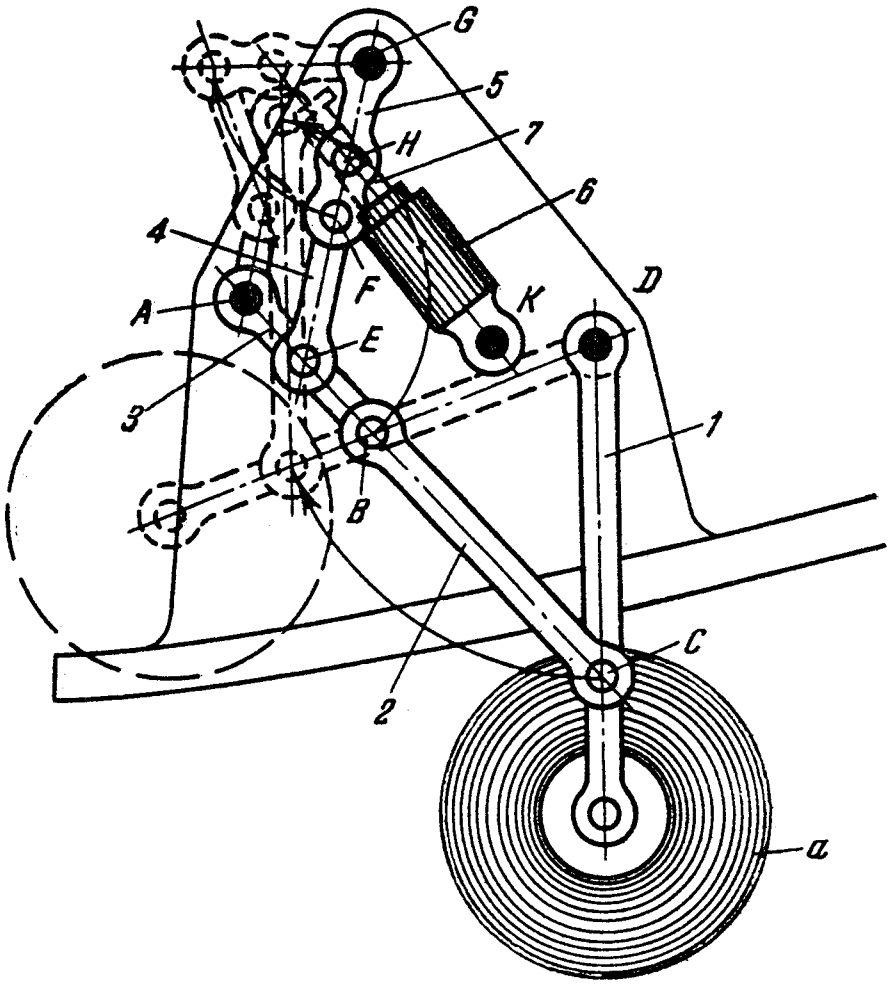

Link *1* with wheel *a* turns about fixed axis *D* of the aircraft frame member. Link *2*, provided with a shock absorber, is connected by turning pairs *B* and *C* to links *3* and *1*. Link *3* turns about fixed axis *A* of the aircraft frame. Piston rod *5* of retracting cylinder *4* is connected by turning pair *E* to link *3*. Cylinder *4* turns about fixed axis *F* of the aircraft frame. When piston rod *5* moves into retracting cylinder *4*, links *1* and *3* are turned counterclockwise, and the landing gear is retracted as shown by the dash lines.

| 1434 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|



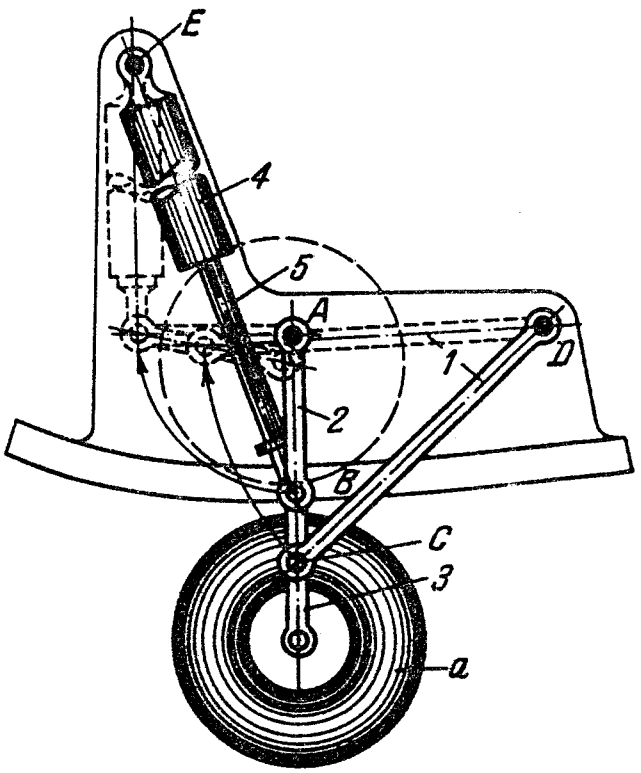

Link *3* turns about fixed axis *A* of the aircraft frame member. Link *2*, provided with a shock absorber, is connected by turning pairs *B* and *C* to links *3* and *1*. Link *1* turns about fixed axis *D* of the aircraft frame. Wheel *a* rotates freely about axis *C*. Piston rod *5* of retracting cylinder *4* is connected by turning pair *E* to link *3*. Cylinder *4* turns about fixed axis *F* of the aircraft frame. When piston rod *5* moves into retracting cylinder *4*, link *1* is turned clockwise and link *3* counterclockwise, and the landing gear is retracted as shown by the dash lines.

| 1435 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|



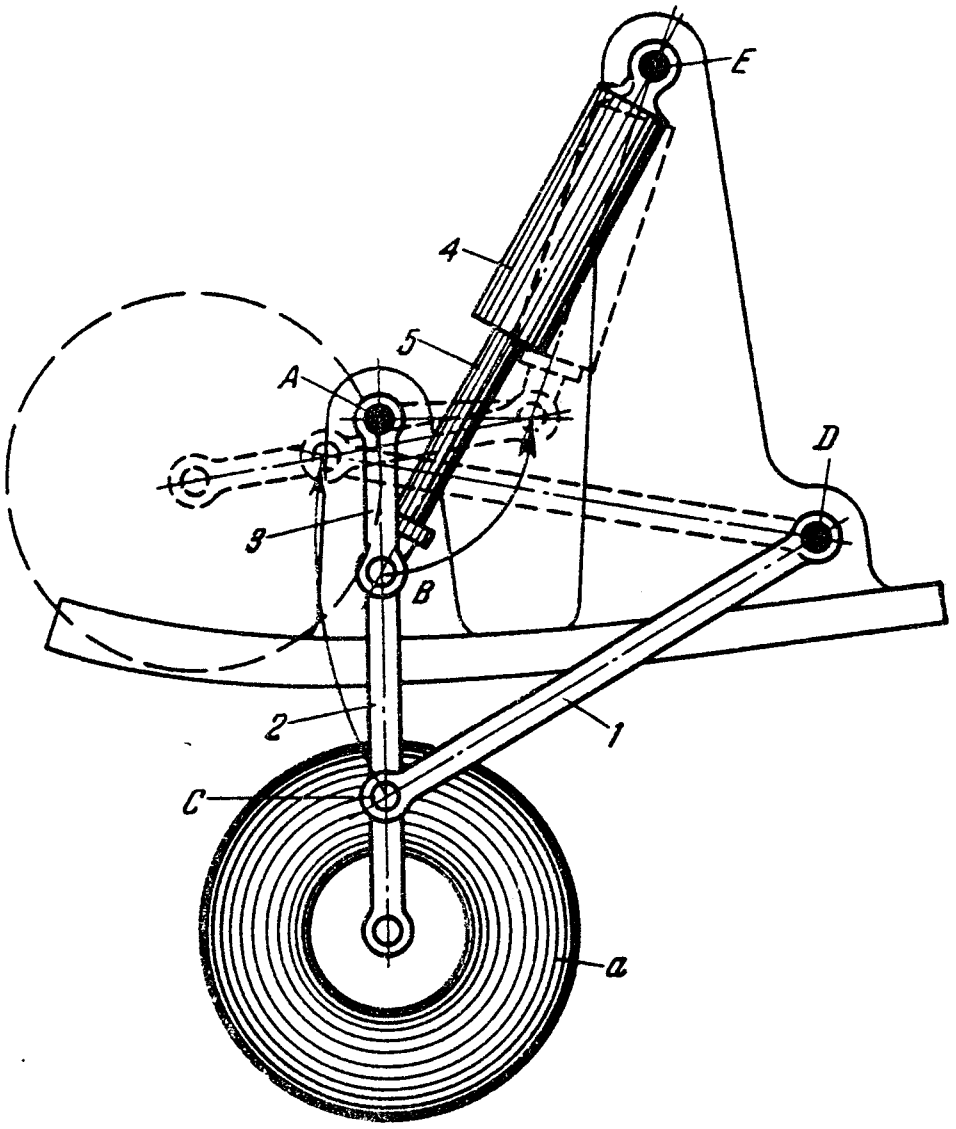

Link *3* turns about fixed axis *A* of the aircraft frame member. Link *2* is connected by turning pairs *B* and *C* to links *3* and *1*. Link *1* with wheel *a* turns about fixed axis *D* of the aircraft frame. Link *4* is connected by turning pairs *E* and *F* to links *3* and *5*. Link *5* turns about fixed axis *G* of the aircraft frame. Piston rod *7* of retracting cylinder *6* is connected by turning pair *H* to link *5*. Cylinder *6* turns about fixed axis *K* of the aircraft frame. When piston rod *7* moves into retracting cylinder *6*, links *1* and *5* are turned clockwise and link *3* counterclockwise, and the landing gear is retracted as shown by the dotted line. When the landing gear is lowered, links *2* and *3*, and *4* and *5* are fixed in their extreme (dead centre) positions, forming a truss.

| 1436 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|



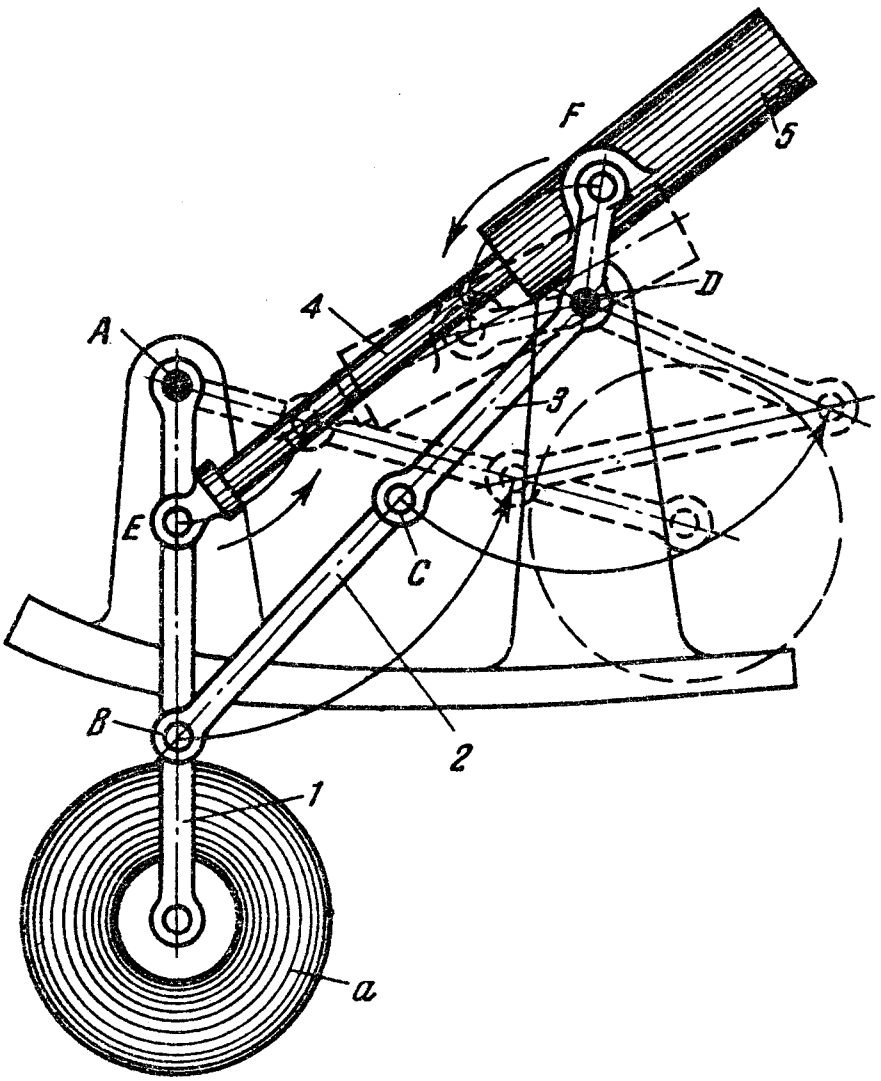

Link *2* turns about fixed axis *A* of the aircraft frame member. Link *3* with wheel *a* is connected by turning pairs *B* and *C* to links *2* and *1*. Link *1* turns about fixed axis *D* of the aircraft frame. Piston rod *5* of retracting cylinder *4* is connected by turning pairs *B* to links *2* and *3*. Cylinder *4* turns about fixed axis *E* of the aircraft frame. When piston rod *5* moves into retracting cylinder *4*, links *1* and *2* are turned clockwise, and the landing gear is retracted as shown by the dash lines.

| 1437 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|



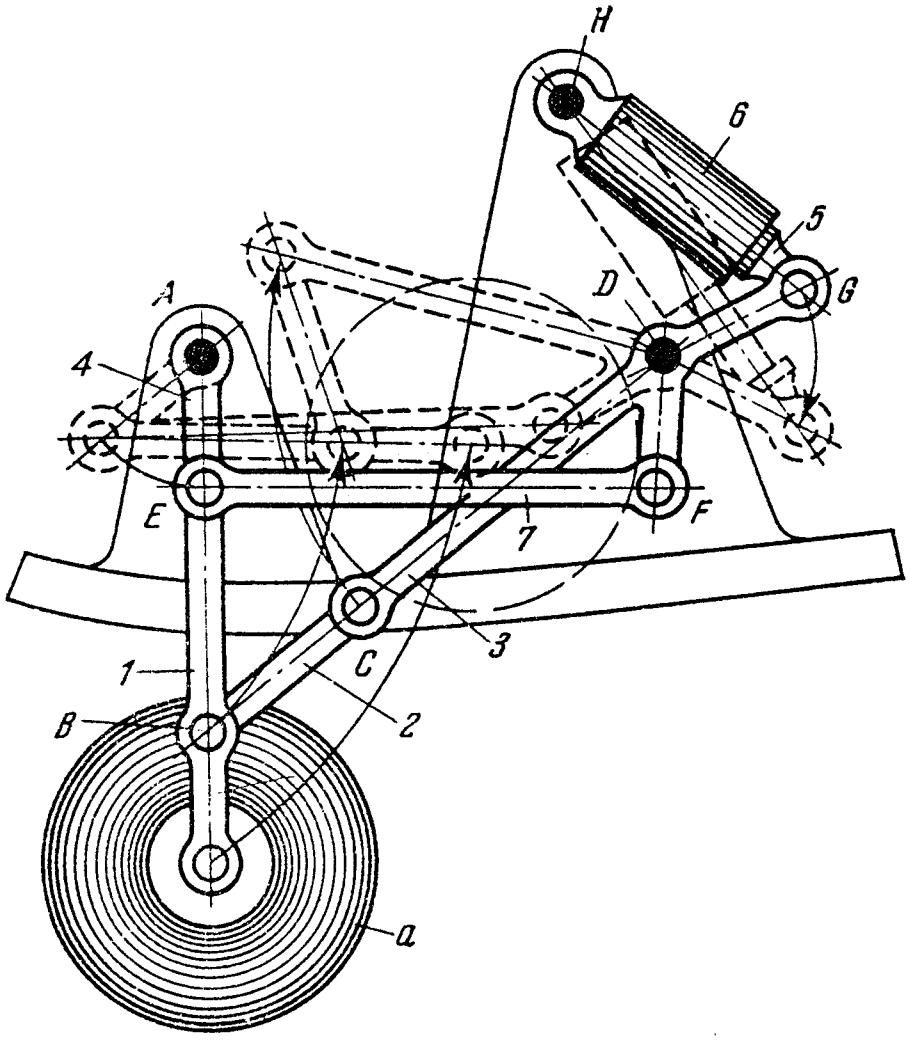

Link *1* turns about fixed axis *D* of the aircraft frame member. Link *2* with wheel *a* is connected by turning pairs *B* and *C* to links *3* and *1*. Link *3* turns about fixed axis *A* of the aircraft frame. Piston rod *5* of retracting cylinder *4* is connected by turning pairs *B* to links *2* and *3*. Cylinder *4* turns about fixed axis *E* of the aircraft frame. When piston rod *5* moves into retracting cylinder *4*, link *1* is turned clockwise and link *3* counterclockwise, and the landing gear is retracted as shown by the dash lines.

| 1438 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|



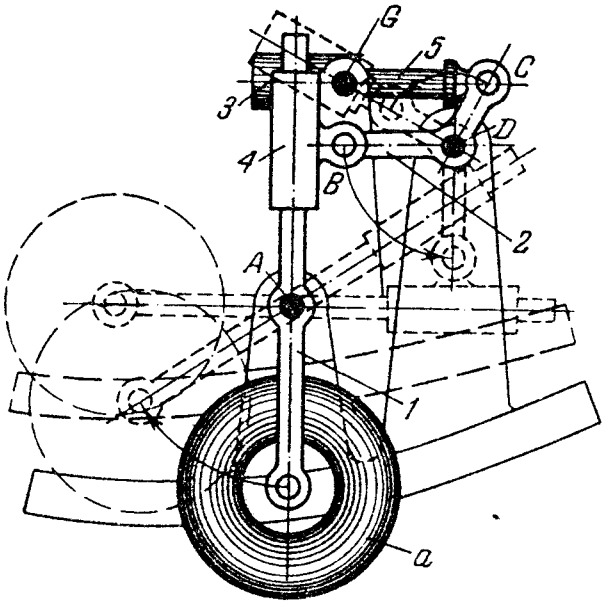

Link *1* with wheel *a* turns about fixed axis *A* of the aircraft frame member. Link *2* is connected by turning pairs *B* and *C* to links *1* and *3*. Link *3* turns about fixed axis *D* of the aircraft frame. Piston rod *4* of retracting cylinder *5* is connected by turning pair *E* to link *1*. Cylinder *5* is connected by turning pair *F* to link *3*. When piston rod *4* moves into retracting cylinder *5*, links *1* and *3* are turned counterclockwise, and the landing gear is retracted as shown by the dash lines.

| 1439 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|



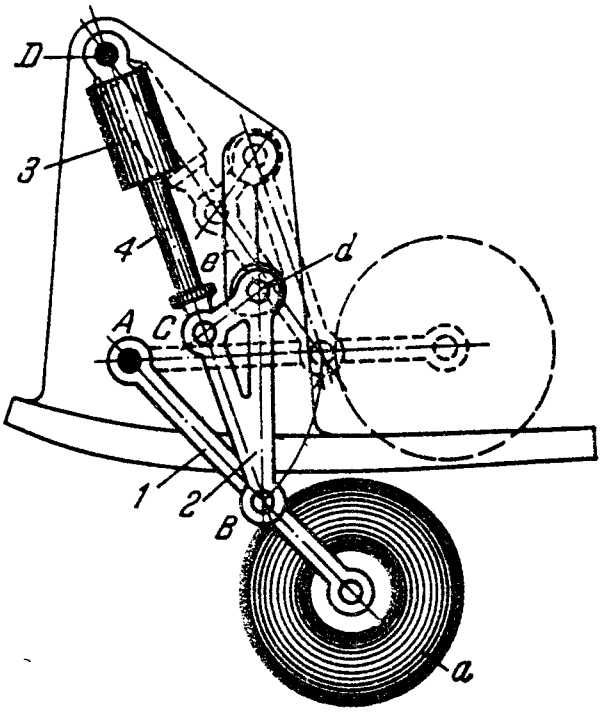

The lengths of the links comply with the conditions: $\overline{AE} = \overline{DF}$ and $\overline{EF} = \overline{AD}$, i.e. figure *AEFD* is a parallel-crank linkage. Links *4* and *3* turn about fixed axes *A* and *D* of the aircraft frame member. Link *1* with wheel *a* is connected by turning pairs *B* and *E* to links *2* and *4*. Link *2* is connected by turning pair *C* to link *3*. Piston rod *5* of retracting cylinder *6* is connected by turning pair *G* to link *3*. Cylinder *6* turns about fixed axis *H* of the aircraft frame. When piston rod *5* moves out of retracting cylinder *6*, link *1* is turned counterclockwise and link *3* clockwise, and the landing gear is retracted, as shown by the dash lines. When the landing gear is lowered, links *1* and *4*, and *2* and *3* are fixed in their extreme (dead centre) positions, forming a truss.

| 1440 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|



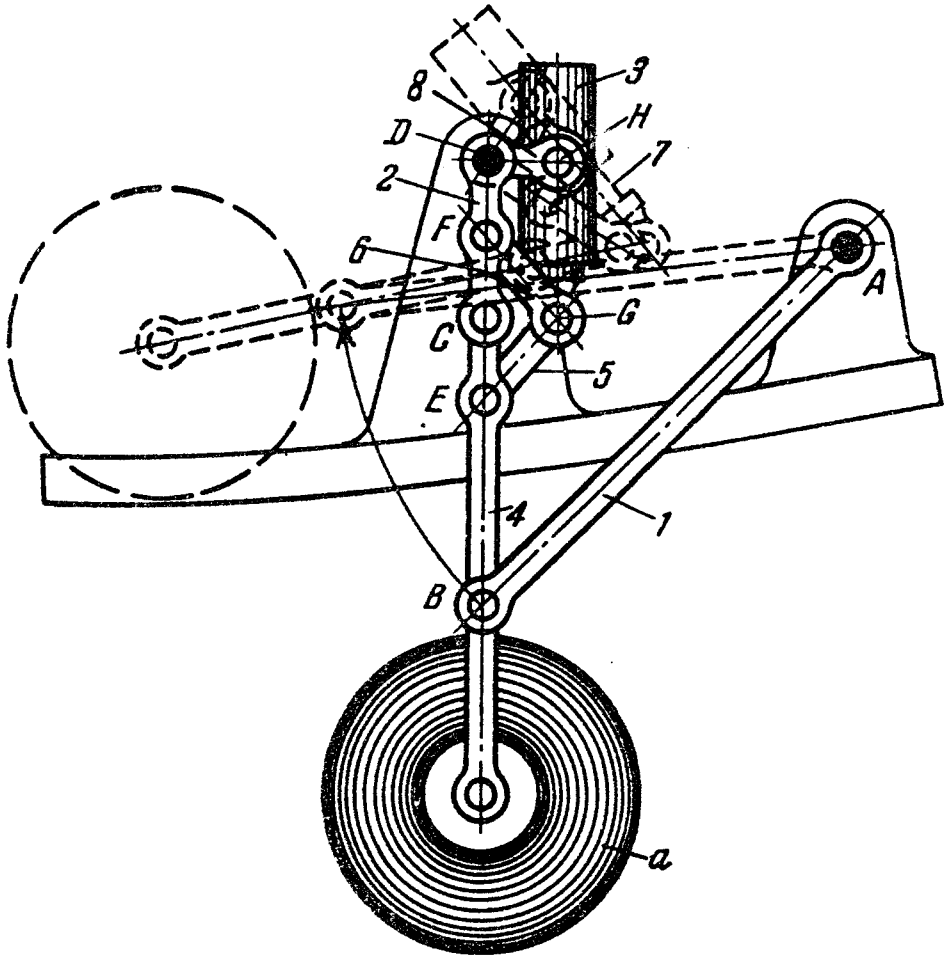

Link *1* with wheel *a* turns about fixed axis *A* of the aircraft frame member. Slider *4* moves along the axis of link *1* and is connected by turning *B* to link *2* which turns about fixed axis *D* of the aircraft frame. Piston rod *5* of retracting cylinder *3* is connected by turning pair *C* to link *2*. Cylinder *3* turns about fixed axis *G* of the aircraft frame. When piston rod *5* moves into retracting cylinder *3*, link *1* is turned clockwise and link *2* counterclockwise, and the landing gear is retracted as shown by the dash lines.

| 1441 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|



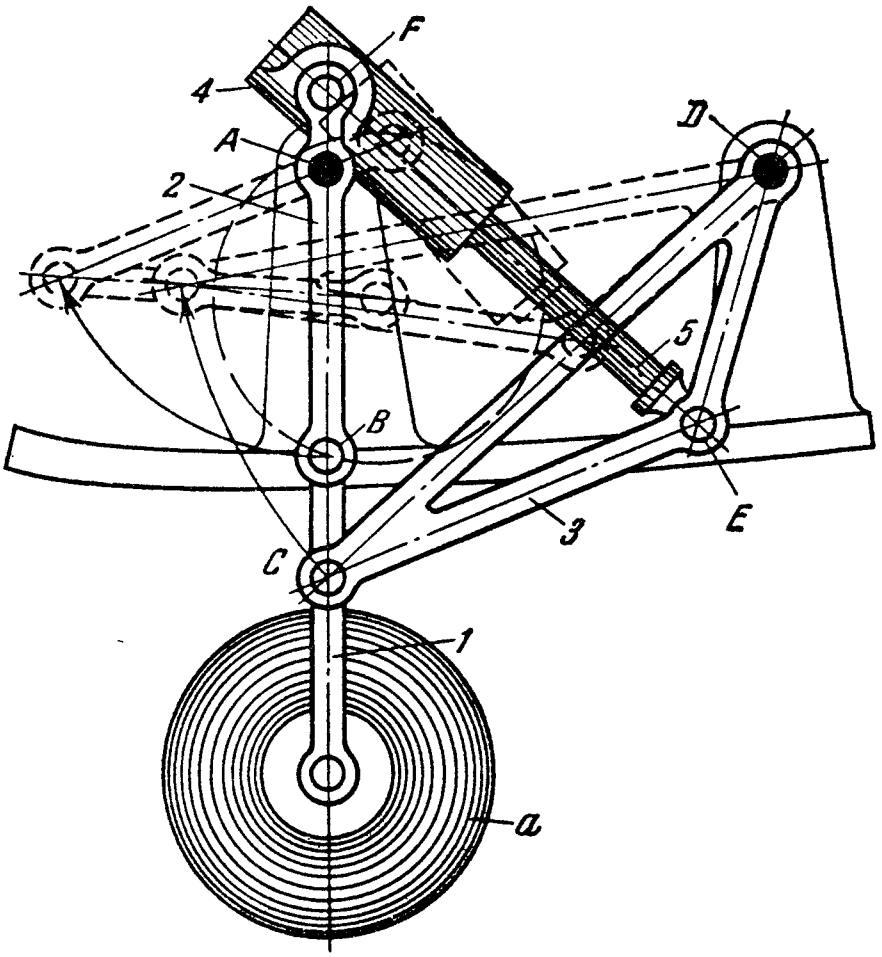

Link *1* with wheel *a* turns about fixed axis *A* of the aircraft frame member. Link *2* is connected by turning pairs *B* and *C* to links *1* and piston rod *4* of retracting cylinder *3*. Cylinder *3* turns about fixed axis *D* of the aircraft frame. Link *2* has roller *d* which slides freely along slot *e* of the aircraft frame. When piston rod *4* moves into retracting cylinder *3*, link *1* turns counterclockwise, and the landing gear is retracted as shown by the dash lines. At the extreme positions of link *2*, its roller *d* enters notches of slot *e* thereby relieving the load on the retracting cylinder.

| 1442 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|




Link *1* turns about fixed axis *A* of the aircraft frame member. Link *4* with wheel *a* is connected by turning pairs *B* and *C* to links *1* and *2*. Link *2* turns about fixed axis *D* of the aircraft frame. Links *5* and *6* are of equal length, they are connected together by turning pair *G*, and by turning pairs *E* and *F* to links *4* and *2*. Piston rod *7* of retracting cylinder *3* is connected by turning pairs *G* to links *5* and *6*. Cylinder *3* is connected by turning pair *H* to link *8* which turns about fixed axis *D*. When piston rod *7* moves out of retracting cylinder *3*, link *1* is turned clockwise, and the landing gear is retracted as shown by the dash lines.

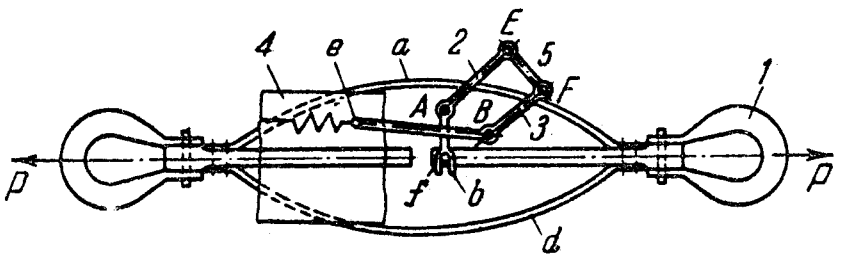
| 1443 | LINK-GEAR RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | LG AL |
|---|---|---|




Link *2* turns about fixed axis *A* of the aircraft frame member. Link *1* with wheel *a* is connected by turning pairs *B* and *C* to links *2* and *3*. Link *3* turns about fixed axis *D* of the aircraft frame. Piston rod *5* of retracting cylinder *4* is connected by turning pair *E* to link *3*. Cylinder *4* is connected by turning pair *F* to link *2*. When piston rod *5* moves into retracting cylinder *4*, links *2* and *3* are turned clockwise, and the landing gear is retracted as shown by the dash lines.

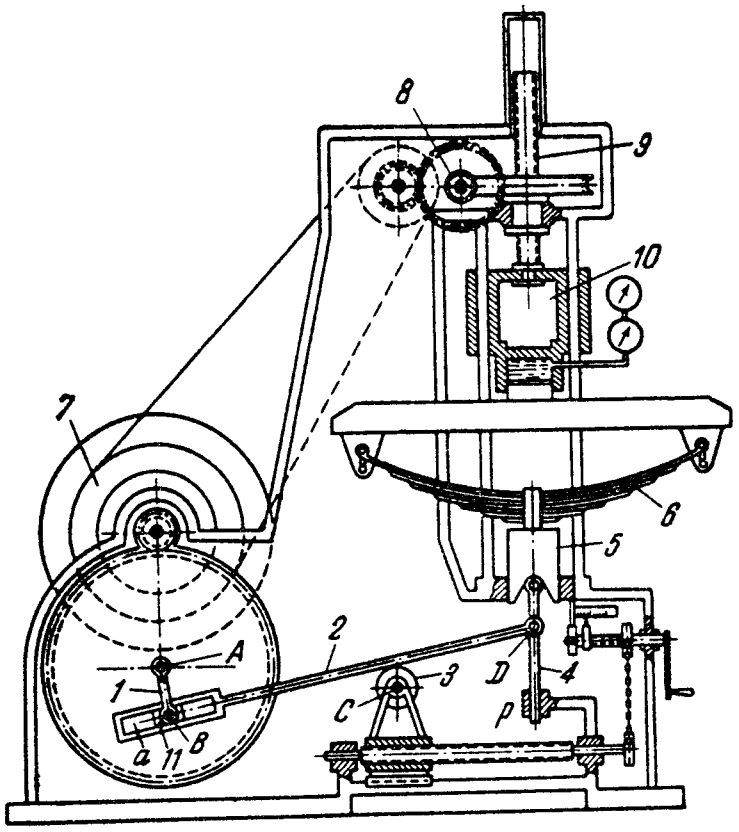
# 22. MECHANISMS OF MEASURING AND TESTING DEVICES (1444 and 1445)

| 1444 | TENSILE LINK-GEAR DYNAMOGRAPH | LG M |
|---|---|---|




Link *2* turns about fixed axis *A* and has fork *f* which engages pin *b* of link *1*. Link *5* is connected by turning pairs *E* and *F* to link *2* and to link *3* which turns about fixed axis *B*. Pulling force *P*, applied to the shackle of link *1*, is transmitted by two flat springs *a* and *d* which are straightened out and thereby cause horizontal displacement of pin *b*, turning levers *2* and *3*. Pencil *e*, mounted on lever *3*, draws a diagram of the pulling force on moving paper band *4*.

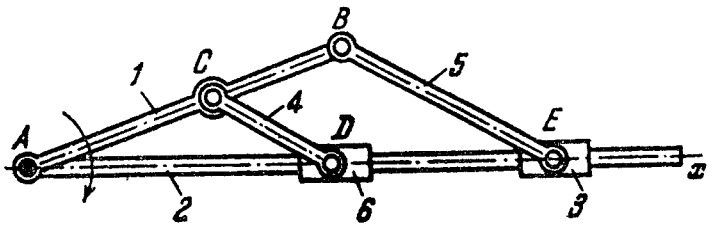
| 1445 | LINK-GEAR MECHANISM OF A DYNAMIC LEAF SPRING TESTING MACHINE | LG M |
|---|---|---|




Crank *1* turns about fixed axis *A* and is connected by turning pair *B* to slider *11* which moves along slot *a* of slotted link *2*. Slotted link *2* rolls along roller *3* which rotates about fixed axis *C*. Link *2* is connected by turning pair *D* to link *4* which slides in fixed guide *p*. Link *4* actuates plunger *5*. When crank *1* rotates about axis *A*, link *2*, bearing on roller *3*, applies an alternating load through link *4* and plunger *5* on leaf spring *6* being tested. Roller *3* can be adjusted in the horizontal direction, varying the distance $\overline{AC}$ and, thereby, the upward stroke of plunger *5*. The machine can also be employed for the static testing of leaf springs. In this case the machine is powered through belt drive *7*, worm gearing *8*, screw *9* and plunger *10*.

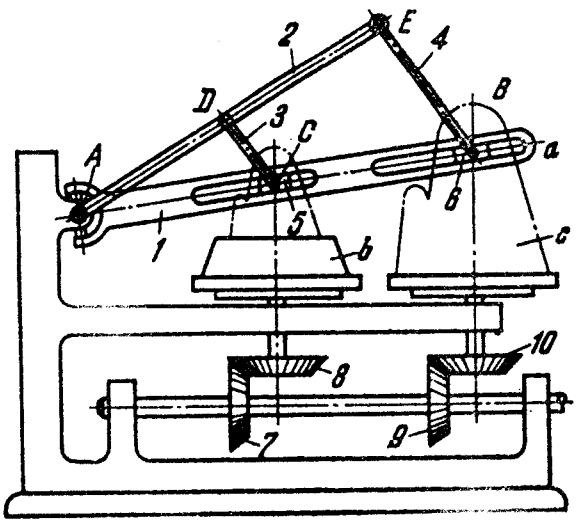
# 23. PANTOGRAPH MECHANISMS (1446 and 1447)

| 1446 | LINK-GEAR PANTOGRAPH MECHANISM WITH TWO SLIDERS | LG P |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AC} : \overline{AB} = \overline{CD} : \overline{BE}$. Link *1* and sliding link *2* turn about fixed axis *A*. Links *4* and *5* are connected by turning pairs *C* and *B* to link *1*, and by turning pairs *D* and *E* to sliders *6* and *3* which move along axis *Ax* of sliding link *2*. When link *1* turns about axis *A*, selected as the centre of similarity, and one of the points *D* or *E* travels along any arbitrary path, the other point describes a similar path. The mechanism has reversibility since any point, *A*, *D* or *E*, can be selected as the centre of similarity.

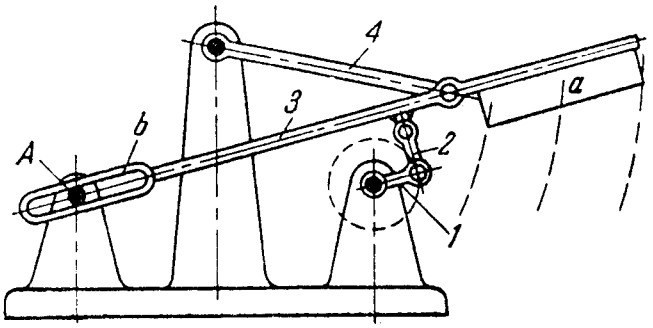
| 1447 | LINK-GEAR SPATIAL MECHANISM OF A COPYING DEVICE | LG P |
|---|---|---|




The lengths of the links comply with the condition: $\overline{DC} : \overline{EB} = \overline{AD} : \overline{AE}$. Points *A*, *C* and *B* lie on straight line *Aa*. Thus links *1*, *2*, *3*, *4*, *5* and *6* constitute a pantograph. The forked end of link *1* can turn about pivot *A* both in the plane of the drawing and in a plane perpendicular to the drawing. Points *C* and *B* describe similar three-dimensional motions. Bevel gears *7*, *8*, *9* and *10* rotate objects *b* and *c* that are being copied.

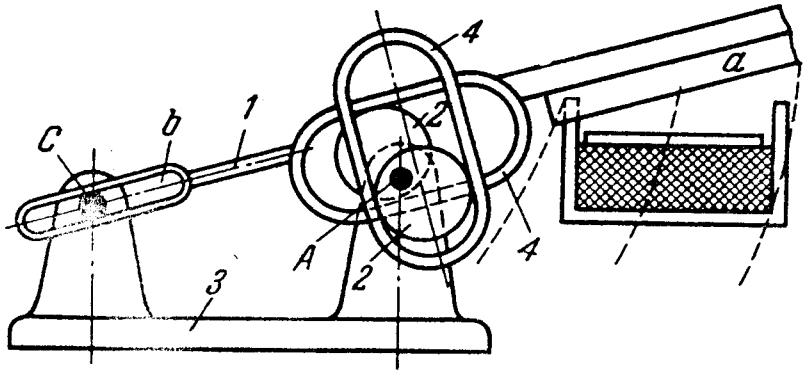
# 24. MECHANISMS OF OTHER FUNCTIONAL DEVICES (1448 through 1474)

| 1448 | LINK-GEAR KNIFE MECHANISM | LG FD |
|---|---|---|



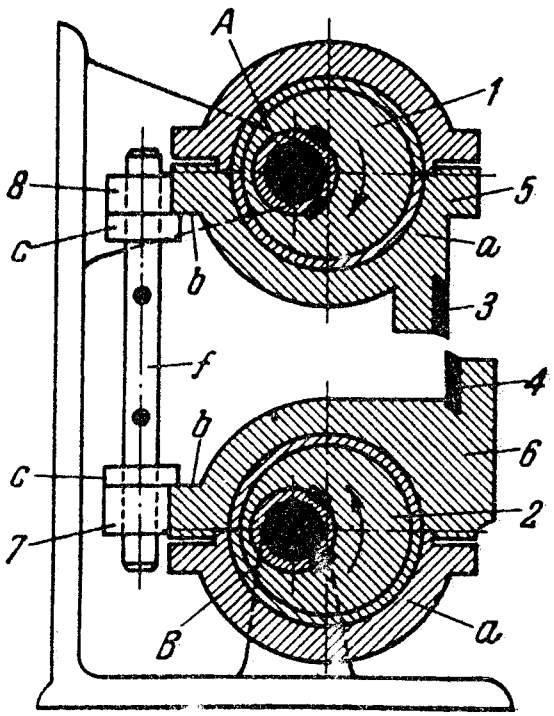

Through intermediate link *2* crank *1* imparts complex motion to link *3*. Link *3* is suspended from rod *4* and has slot *b* which slides along fixed pin *A*. Knife *a* is rigidly secured to link *3*.

| 1449 | ECCENTRIC AND SLOTTED-LINK KNIFE MECHANISM | LG FD |
|---|---|---|



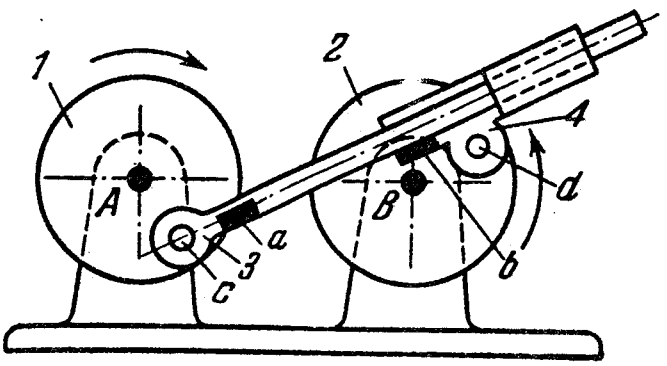

Two eccentrics *2*, rigidly secured to each other, rotate about fixed axis *A*. The eccentrics are enclosed one each, by two frames *4* which are rigidly secured to each [illegible] and are mounted on link *1*. Link *1* has slot *b* which slides along fixed pin *C*. When eccentrics *2* rotate about axis *A*, the required motion is imparted to link *1* and to knife *a* mounted on link *1*.

| 1450 | LINK-GEAR MECHANISM OF A POWER SHEAR | LG FD |
|---|---|---|



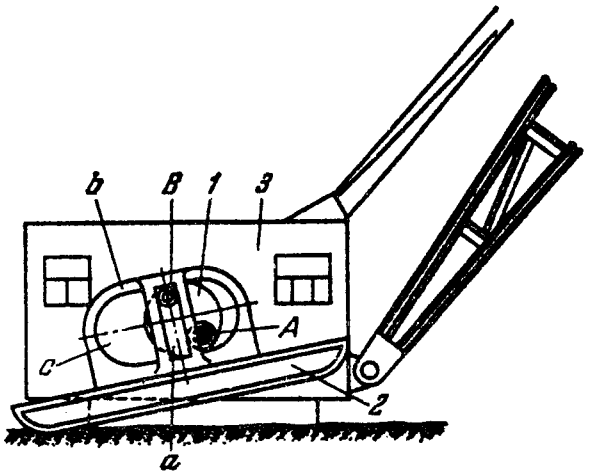

Round eccentrics *1* and *2* rotate about fixed axes *A* and *B*. Links *5* and *6* mount knives *3* and *4*, and have collars *a* encircling eccentrics *1* and *2*. Links *5* and *6* have flat surfaces *b* which slide along flat surfaces *c* of sliders *8* and *7*. Sliders *7* and *8* move along fixed guide *f*. Eccentrics *1* and *2* have independent drives, they rotate with equal angular velocities and have equal angles of rotation in each position. When eccentrics *1* and *2* rotate in opposite directions, knives *3* and *4* have translational motion and cut the material.

| 1451 | LINK-GEAR MECHANISM OF A POWER SHEAR | LG FD |
|---|---|---|



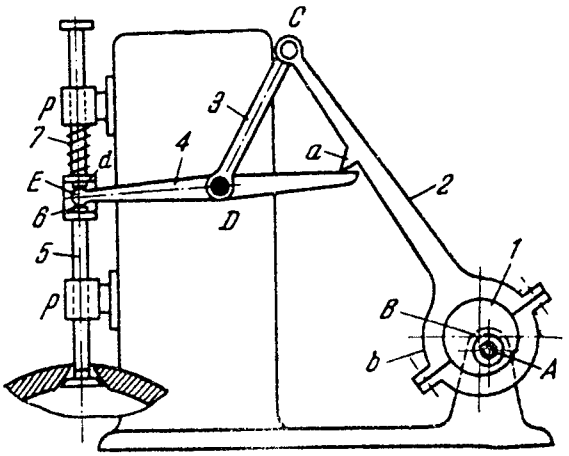

Disks *1* and *2* rotate about fixed axes *A* and *B*. Knives *a* and *b* are mounted on bar *3* and slide *4* which are connected by turning pairs to pins *c* and *d* of disks *1* and *2*. Disks *1* and *2* rotate in opposite directions. Knives *a* and *b* are always parallel to each other. By varying the speeds of rotation of driving disks *1* and *2*, the time when the knives meet may be changed, thereby regulating the cutting process.

| 1452 | ECCENTRIC AND SLOTTED-LINK WALKING MECHANISM OF A DRAGLINE EXCAVATOR | LG FD |
|---|---|---|




Eccentric *1* rotates about fixed axis *A* of frame member (tub) *3*. Shoe *2* has frame *b* with slot *c* whose width equals the diameter of eccentric *1*. Frame *b* also has slot *a* along which pin *B* of eccentric *1* slides. When eccentric *1* rotates about axis *A* it alternately elevates and shifts shoes *2* and frame member *3* forward or backward.

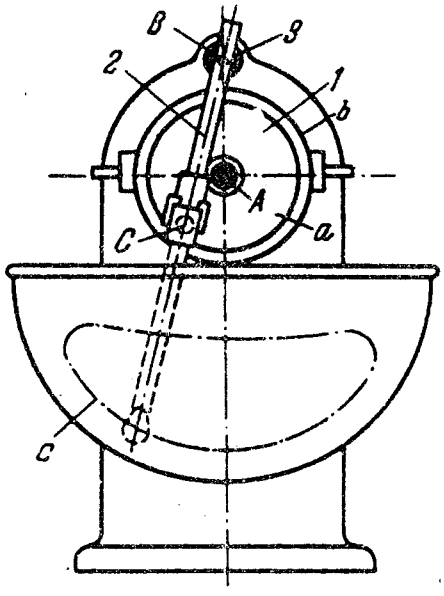
| 1453 | LINK-GEAR ECCENTRIC-TYPE VALVE MECHANISM | LG FD |
|---|---|---|




Connecting rod *2* of four-bar linkage *ABCD* has collar *b* encircling round eccentric *1* which rotates about fixed axis *A*. Lever *4* turns about fixed axis *D* and is connected by turning pair *E* to slider *6* which moves in slot *d* of valve stem *5*. Stem *5* reciprocates in fixed guides *p-p*. When eccentric *1* rotates about axis *A*, lug *a* of connecting rod *2* describes a connecting-rod curve in which it turns lever *4* to raise valve stem *5*. At a certain point in its path lug *a* slips off lever *4* and the valve is pushed downward by spring *7*.

## 1454 LINK-GEAR MECHANISM OF A DOUGH KNEADING MACHINE

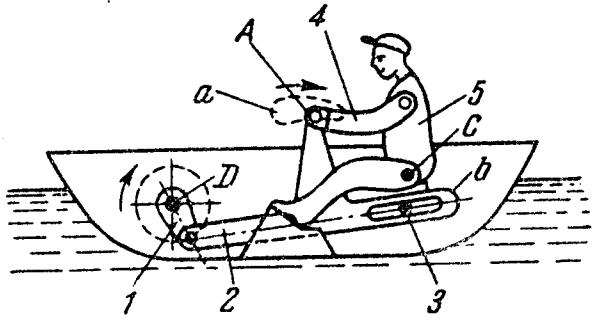
LG FD




Crank *1*, rotating about fixed axis *A*, is designed in the form of disk *a* rotating in fixed ring *b*. Connecting rod *2* is connected by turning pair *C* to crank *1*. The upper end of connecting rod *2* slides in link *3* which turns about fixed axis *B*. When crank *1* rotates about axis *A*, the lower end of connecting rod *2* describes connecting-rod curve *c* which is used for the kneading operation. The shape of the curve can be varied by axial adjustment of connecting rod *2*, clamping it in the required position.

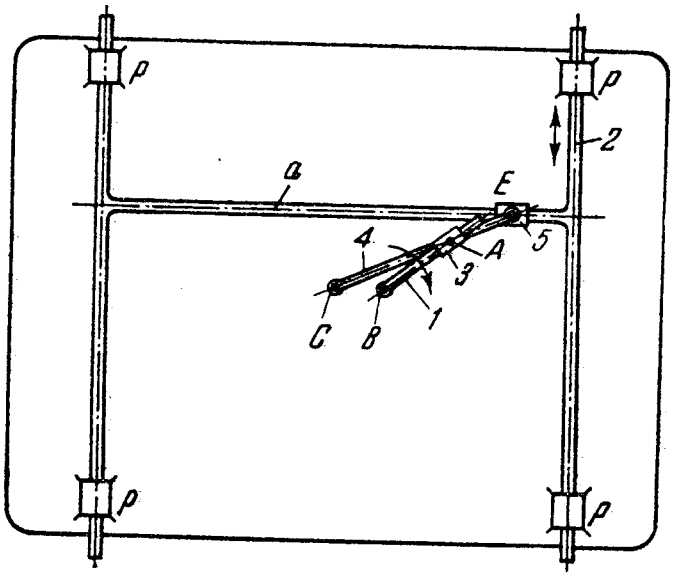
## 1455 LINK-GEAR MECHANISM OF A TOY ROWER

LG FD



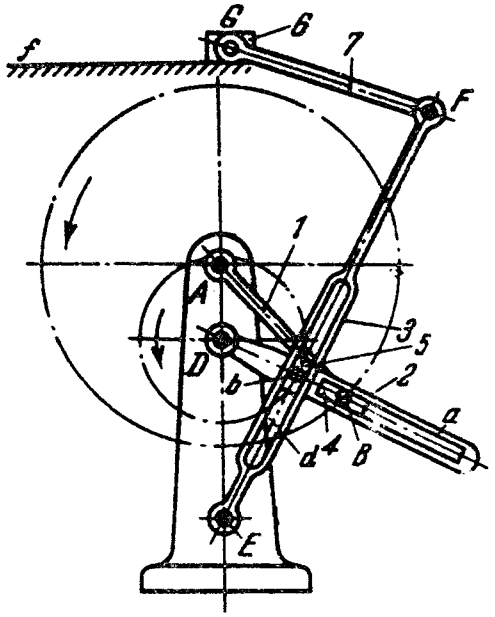

Crank *1* rotates about axis *D* fixed in the boat. When crank *1* rotates, connecting rod *2*, having slot *b*, slides along pin *3* fixed in the boat. At this, point *A* of connecting rod *2* describes connecting-rod curve *a* as a result of which arms *4* holding the oars and body *5* of the oarsman, oscillating about axis *C*, are imparted the required motions.

| 1456 | LINK-GEAR SHAPER MECHANISM | LG<br>FD |
|---|---|---|

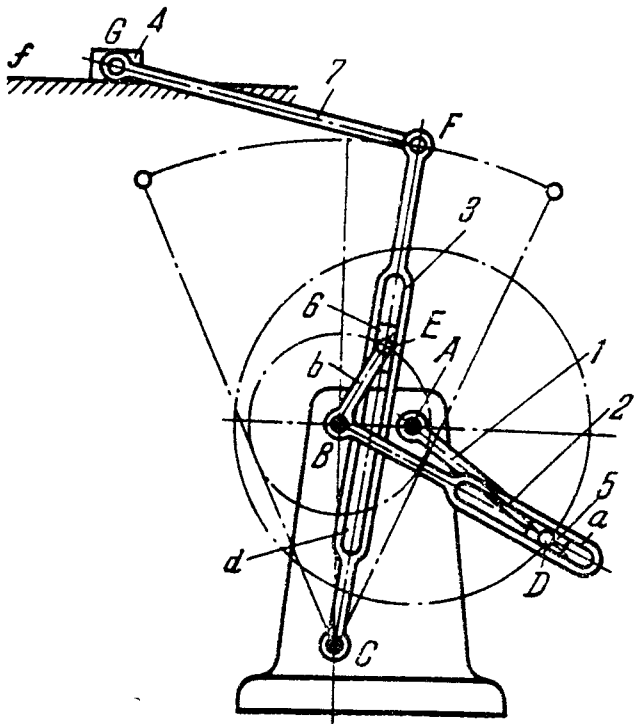



Sliding link *1* rotates about fixed axis *B* and is connected by a sliding pair to slider *3* which, in turn, is connected by turning pair *A* to link *4*. Link *4* turns about fixed axis *C* and is connected by turning pair *E* to slider *5* which moves along guide *a* of link *2*. Link *2* reciprocates in fixed guides *p-p*. When sliding link *1* rotates at uniform velocity about axis *B*, link *2* travels with approximately uniform velocity over a part of its forward stroke.

| 1457 | LINK-GEAR SHAPER MECHANISM | LG FD |
|---|---|---|

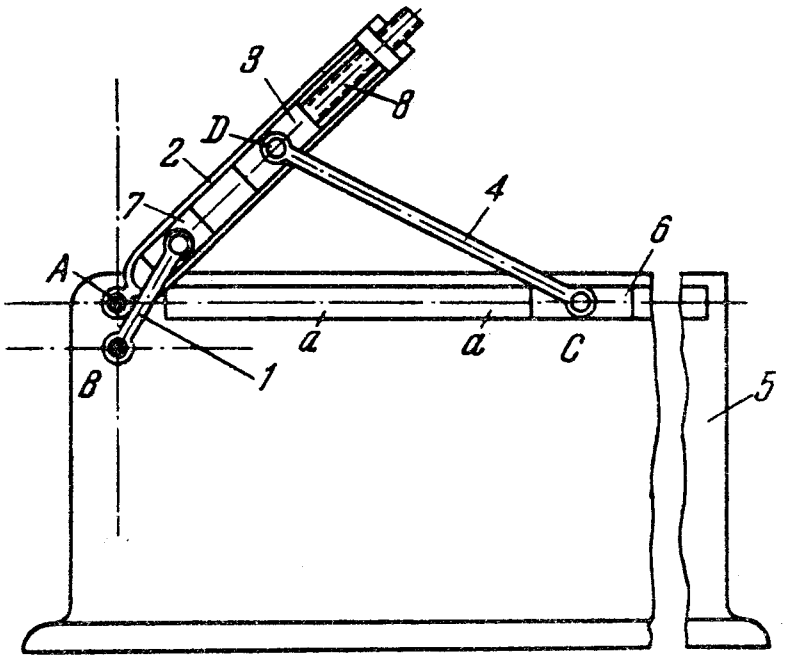



Crank *1* rotates about fixed axis *A* and is connected by turning pair *B* to slider *4* which moves along slot *a* of link *2*. Slotted link *2* rotates about fixed axis *D*. Pin *b* of slotted link *2* is connected by a turning pair to slider *5* which moves along slot *d* of slotted link *3*. Slotted link *3* turns about fixed axis *E* and is connected by turning pair *F* to connecting rod *7* which, in turn, is connected by turning pair *G* to slider *6*. Slider *6* reciprocates along fixed guide *f*. When crank *1* rotates at uniform velocity about axis *A*, slotted link *2* rotates at nonuniform velocity, slotted link *3* oscillates and slider *6* travels with approximately uniform velocity over a part of its reciprocating motion.



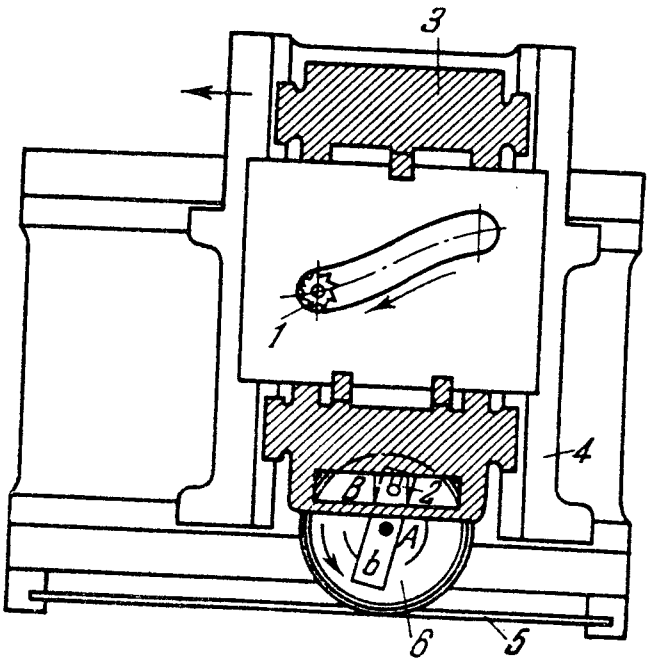

Crank *1* rotates about fixed axis *A* and is connected by turning pair *D* to slider *5* which moves along slot *a* of link *2*. Slotted link *2* rotates about fixed axis *B* and has extension *b* which is connected by turning pair *E* to slider *6*. Slider *6* moves along slot *d* of slotted link *3* which turns about fixed axis *C*. Slotted link *3* is connected by turning pair *F* to connecting rod *7* which, in turn, is connected by turning pair *G* to slider *4*. Slider *4* reciprocates along fixed guide *f*. When crank *1* rotates at uniform velocity about axis *A*, slotted link *2* rotates at nonuniform velocity, slotted link *3* oscillates and slider *4* travels with approximately uniform velocity over a part of its reciprocating motion.

| 1459 | LINK-GEAR SHAPER MECHANISM | LG FD |
|---|---|---|



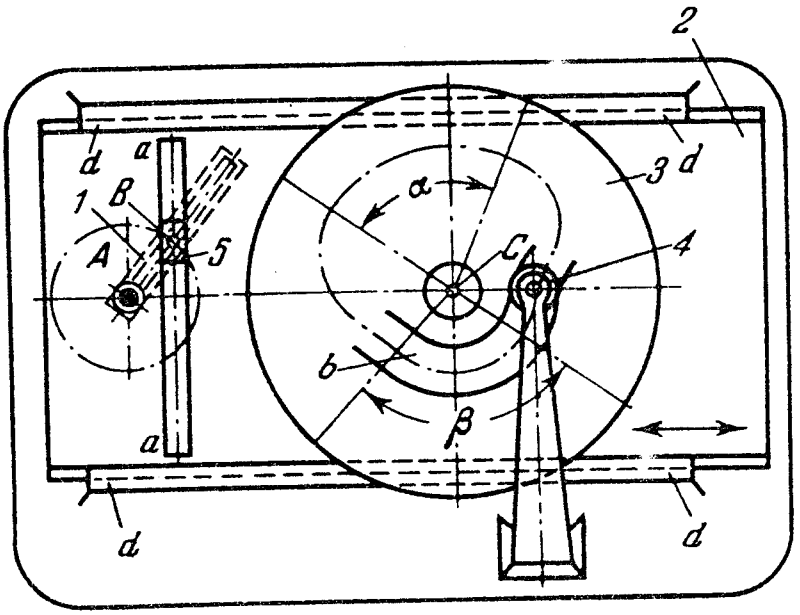

Crank *1* rotates about fixed axis *B* and is connected by a turning pair to slider *7* which moves along the slot of link *2*. Slotted link *2* rotates about fixed axis *A*. Adjustable along slotted link *2* is slider *3* which is set to the required position by screw device *8*. Connecting rod *4* is connected by turning pairs *D* and *C* to sliders *3* and *6*. Slider *6* reciprocates along fixed guides *a-a* of base *5*. When crank *1* rotates about axis *B*, slotted link *2* rotates about point *A* and slider *6* reciprocates along the guides of base *5*. Slider *3*, rigidly clamped in slotted link *2*, serves to change the stroke of point *C*.

| 1460 | LINK-GEAR MECHANISM FOR MILLING SINE-SHAPED CAM SLOTS | LG FD |
|---|---|---|



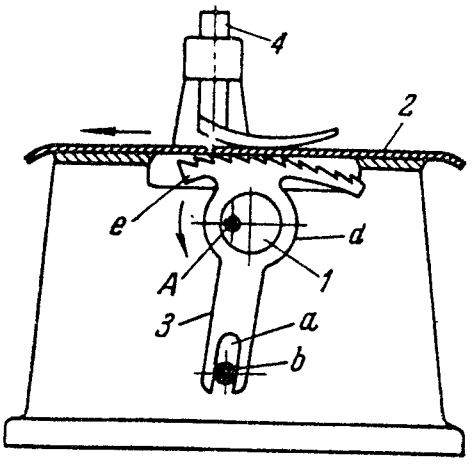

Milling cutter *1* is mounted on the fixed spindle of the milling machine. The workpiece is clamped on plate *3* which is traversed vertically by means of slider *2*. Slider *2* is connected by turning pair *B* to crank *b* which turns about axis *A*. Horizontal travel of plate *3* together with slide *4* is accomplished by the rolling of drum *6* along stretched steel band *5* which runs over drum *6*.

| 1461 | SLOTTED-LINK MECHANISM FOR MILLING SINE-SHAPED CAM SLOTS | LG FD |
|---|---|---|



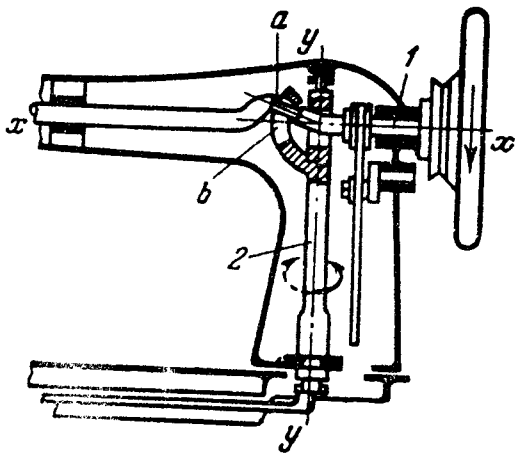

Crank *1* rotates about fixed axis *A* and is connected by turning pair *B* to slider *5* which moves along slot *a-a* of work table *2*. When crank *1* rotates about axis *A*, table *2* reciprocates along guides *d-d*. Disk *3*, mounted on table *2*, is turned by an independent drive about axis *C* of the table. Crank *1* is periodically rotated and held stationary as required. This enables milling cutter *4*, clamped in a fixed position, to mill a slot of profile *b* in disk *3*. The obtained face cam enables simple harmonic motion to be produced with dwells at certain given parts of the profile corresponding to angles $\alpha$ and $\beta$.

| 1462 | LINK-GEAR CLOTH ADVANCER MECHANISM | LG FD |
|---|---|---|




Round eccentric *1* rotates about fixed axis *A*. Link *3* has collar *d* encircling eccentric *1*. Link *3* slides with its slot *a* along fixed pin *b*. Presser foot *4* holds the cloth against serrated member *e* of link *3*. When eccentric *1* rotates counterclockwise, cloth *2* is advanced by serrated member *e*.

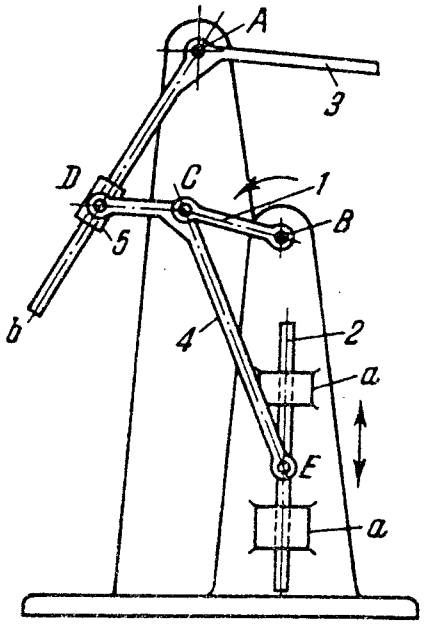
| 1463 | THREE-BAR SPHERICAL SLOTTED-LINK MECHANISM OF A SEWING MACHINE | LG FD |
|---|---|---|




Crank *1*, designed as a bent shaft, rotates about fixed axis *x-x*, its neck *a* sliding along slot *b* of link 2. Link 2 turns about fixed axis *y-y*. When crank *1* rotates, link 2 oscillates about axis *y-y* under the condition that the axes of all the kinematic pairs intersect at a single point.

## 1464 LINK-GEAR NEEDLE AND THREAD-PULLING MECHANISM OF A SEWING MACHINE

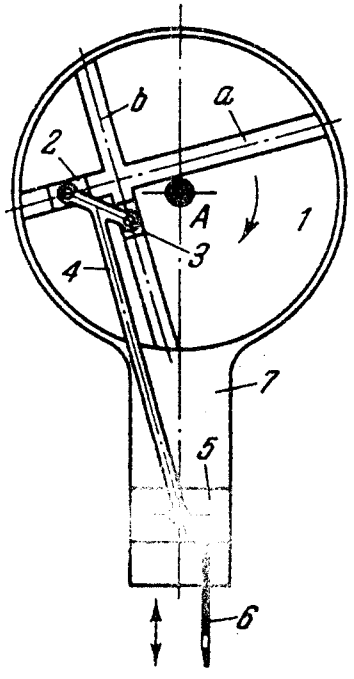
LG FD




Link *4* is connected by turning pairs *C*, *D* and *E* to links *1*, *5* and *2*. Slider *5* moves along arm *Ab* of sliding link *3*. Rod *2* slides in fixed guides *a-a*. Link *3* turns about fixed axis *A*. When crank *1* rotates about fixed axis *B*, needle rod *2* reciprocates and lever *3* of the thread-pulling device oscillates about axis *A*.

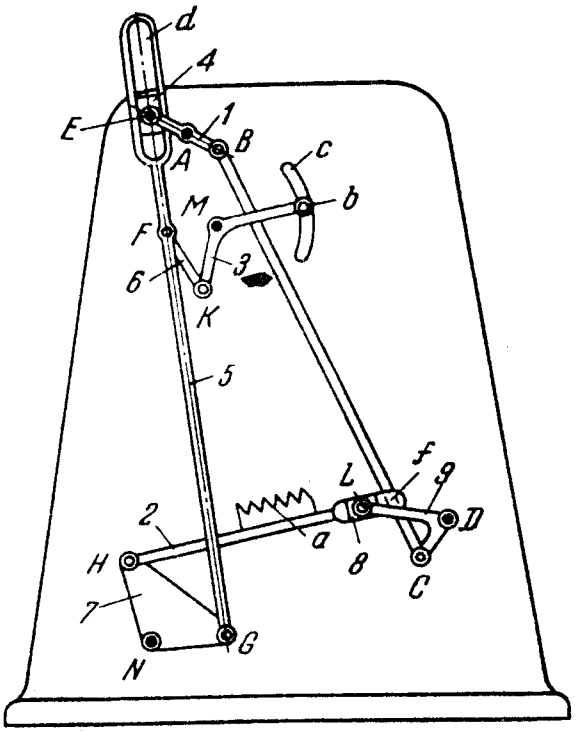
## 1465 LINK-GEAR NEEDLE MECHANISM OF A SEWING MACHINE

LG FD



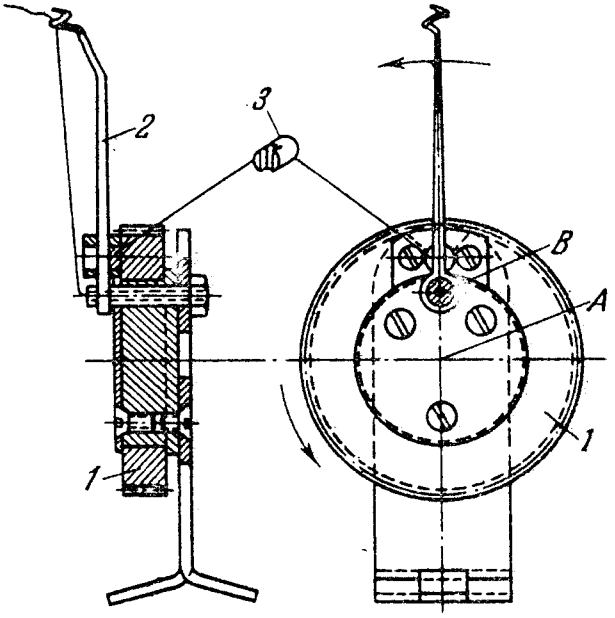

Disk *1* rotates about fixed axis *A* and has grooves *a* and *b* along which sliders *2* and *3* move. Sliders *2* and *3* are connected by turning pairs to connecting rod *4*. When disk *1* rotates, connecting rod *4* imparts reciprocating motion to slider *5* and to needle *6* which is rigidly secured to slider *5*.

| 1466 | LINK-GEAR CLOTH ADVANCER MECHANISM OF A SEWING MACHINE | LG FD |
|---|---|---|



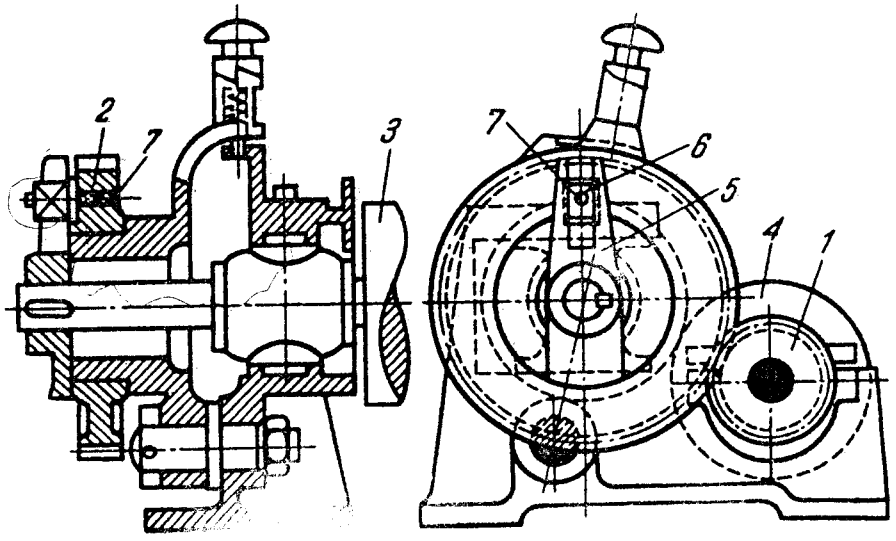

Crank *1* of four-bar linkage *ABCD* rotates about fixed axis *A* and is connected by turning pair *E* to slider *4* which moves along slot *d* of link *5*. Link *5* is connected by turning pairs *F* and *G* to links *6* and *7*. Link *6* is connected by turning pair *K* to link *3* which turns about fixed axis *M* and is fixed by screw *b* in one of the positions in circular groove *c*. Link *7* turns about fixed axis *N* and is connected by turning pair *H* to link *2*. Slider *8* moves along slot *f* of link *2* and is connected by turning pair *L* to rocker arm *9* of four-bar linkage *ABCD*. Rocker arm *9* turns about fixed axis *D*. When crank *1* rotates about axis *A*, serrated member *a*, mounted on link *2*, has a complex motion in which it grips and advances the cloth being sewn. Link *3* regulates the stitch length.

| 1467 | FOUR-BAR SLOTTED-LINK THREAD-CATCHING MECHANISM | LG FD |
|---|---|---|



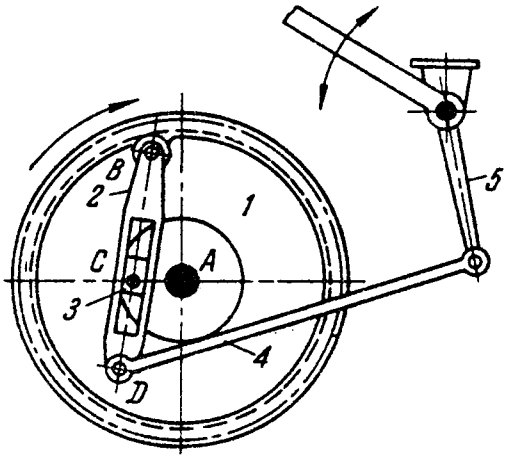

Gear *1* rotates about fixed axis *A*. Link *2*, carrying the guiding hook for the thread, turns about fixed axis *B*. Link *2* slides in guide *3* whose axis of rotation is in gear *1*. When gear *1* rotates at uniform velocity, link *2* rotates at nonuniform velocity.

| 1468 | FOUR-BAR SLOTTED-LINK ROLL MECHANISM | LG FD |
|---|---|---|



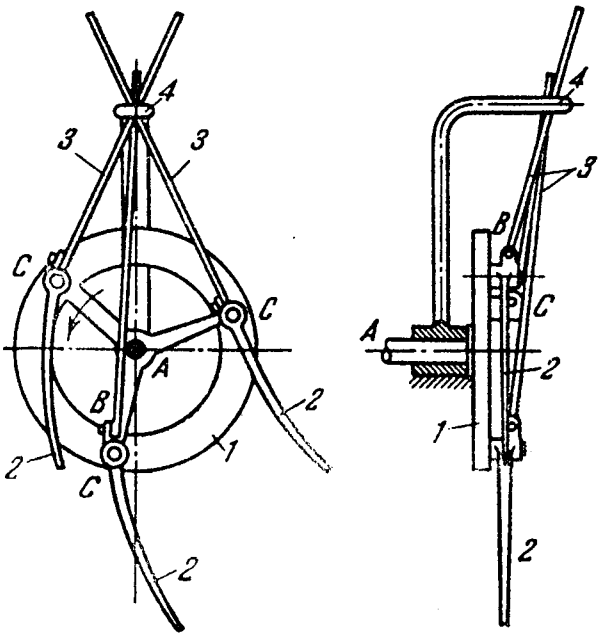

Rotation is transmitted from gear *2* to roll *3* by slider *6* and slotted link *5*. Slider *6* turns on pin *7* mounted in gear *2*. Slotted link *5* is rigidly secured to roll *3*. The mechanism enables the distance to be varied between the axis of roll *3*, and the axis of roll *4* and gear *1*.

| 1469 | LINK-GEAR INKING MECHANISM OF A PRINTING MACHINE | LG FD |
|---|---|---|



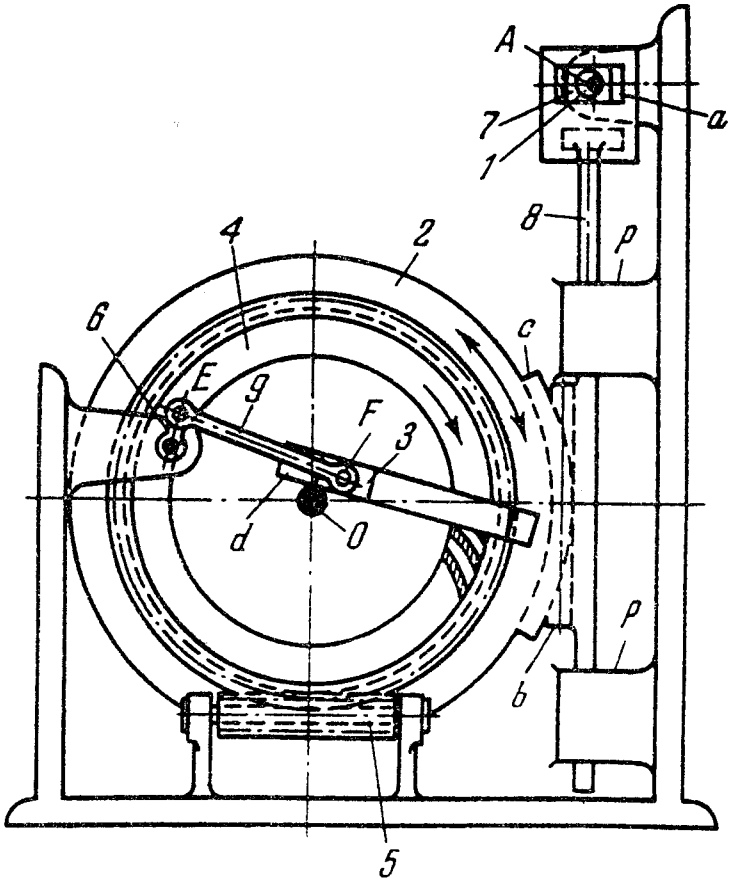

Wheel *1* actuates slotted link *2* which moves along slider *3*. Slider *3* turns about fixed axis *C*. Through intermediate link *4*, oscillating motion is transmitted to lever *5*.

| 1470 | LINK-GEAR SPATIAL MECHANISM OF A POTATO DIGGER | LG FD |
|---|---|---|



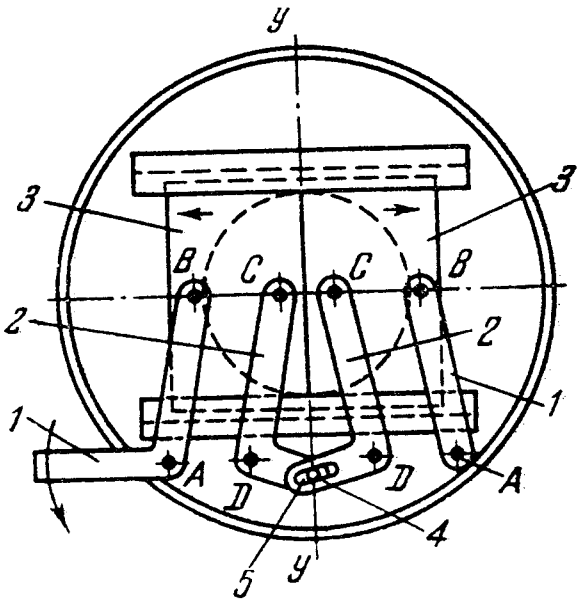

Tines *2* rotate about axes *C* mounted in wheel *1* which rotates about fixed axis *A*. Rods *3* turn about axes *B* which are perpendicular to axes *C*. The ends of rods *3* pass through fixed ring *4*. When wheel *1* rotates, a complex digging motion is transmitted to tines *2*.

| 1471 | LINK-GEAR MECHANISM OF A GEAR-CUTTING MACHINE | LG FD |
|---|---|---|



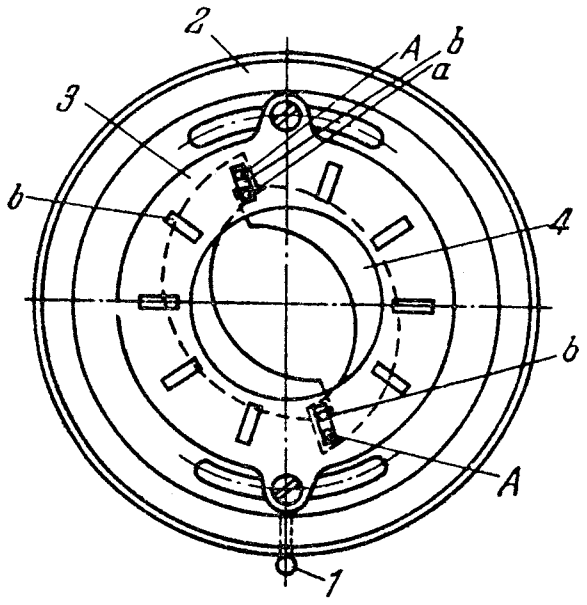

Link *1* is a round eccentric that rotates about fixed axis *A*. Slider *7*, encircling eccentric *1*, moves along slot *a* of link *8* which, in turn, slides in fixed guides *p-p*. Gear rack *b* of link *8* meshes with segment gear *c* of link *2* which turns about fixed axis *O*. Moving along slot *d* of link *2* is slider *3* which is driven by connecting rod *9*. Connecting rod *9* is connected by turning pairs *F* and *E* to slider *3* and link *6*. When eccentric *1* rotates about axis *A*, link *2* oscillates about axis *O*. Gear blank *4* on which teeth are to be cut is rotated by worm *5*. When crank *6* rotates, the cutting tool, mounted on slider *3*, cuts teeth on blank *4*.

| 1472 | LINK-GEAR MECHANISM OF A SLIT DIAPHRAGM | LG FD |
|---|---|---|



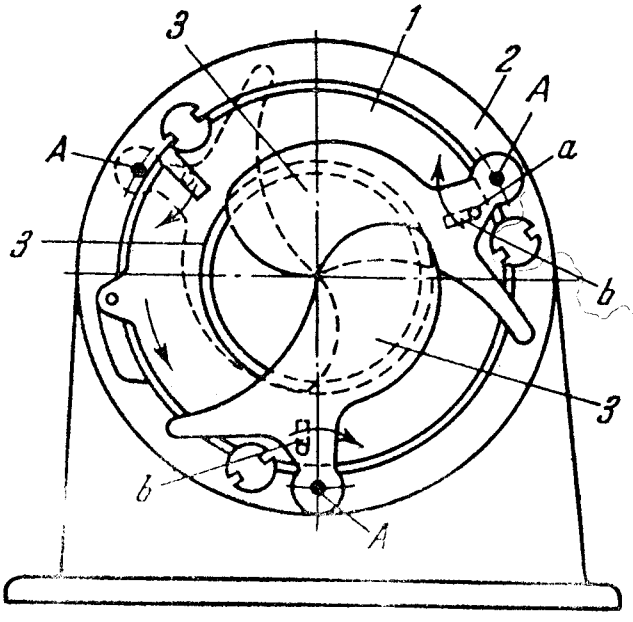

The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$ and $\overline{AD} = \overline{BC}$. The links of the mechanism are arranged symmetrically with respect to axis *y-y*. Each half *3* of the diaphragm with levers *1* and *2* forms a parallel-crank linkage *ABCD*. When lever *1* turns about fixed axis *A*, lever *2* is turned and the action of pin *4* sliding along slot *5* turns the second lever *2*. This retracts the two halves of the diaphragm forming a rectangular slit.

| 1473 | LINK-GEAR MECHANISM OF A CAMERA LENS DIAPHRAGM | LG FD |
|---|---|---|




Segments *4* turn about fixed axes *A* of lens mount *2* and have pins *a* entering slots *b* of ring *3*. When ring *3* is turned by lever *1*, segments *4* are turned about points *A* to open or close the aperture of the camera lens.

| 1474 | LINK-GEAR MECHANISM OF A CAMERA LENS SHUTTER | LG FD |
|---|---|---|




Segments *3* turns about fixed axes *A* of lens mount *2* and have pins *a* entering slots *b* of ring *1*. Ring *1* turns in an annular recess of mount *2*. When ring *1* is turned, segments *3* turn clockwise about axes *A*, opening the shutter of the camera lens.

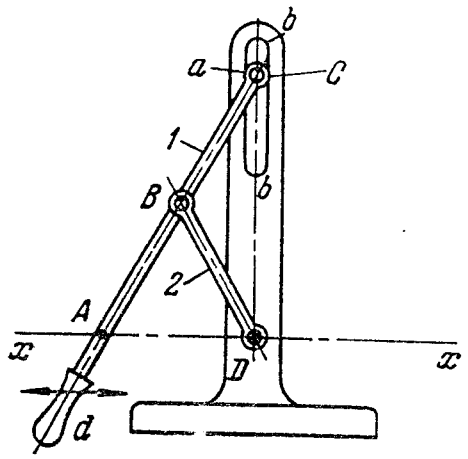
# SECTION FIVE

# Slider-Crank Mechanisms SC

1. General-Purpose Three-Link Mechanisms 3L (1475 and 1476)
2. General-Purpose Four-Link Mechanisms 4L (1477 through 1503)
3. General-Purpose Six-Link Mechanisms 6L (1504 through 1528)
4. General-Purpose Multiple-Link Mechanisms ML (1529 through 1534)
5. Guiding Mechanisms and Inversors GI (1535 through 1559)
6. Piston Machine Mechanisms PM (1560 through 1591)
7. Wobble Plate Mechanisms WP (1592 through 1600)
8. Mechanisms for Mathematical Operations MO (1601 and 1602)
9. Mechanisms for Generating Curves Ge (1603 through 1624)
10. Stop, Detent and Locking Mechanisms SD (1625 through 1628)
11. Hammer, Press and Die Mechanisms HP (1629 through 1633)
12. Governor Mechanisms G (1634 through 1639)
13. Gripping, Clamping and Expanding Mechanisms GC (1640 through 1644)
14. Dwell Mechanisms D (1645 through 1648)
15. Mechanisms of Materials Handling Equipment MH (1649)
16. Operating Claw Mechanisms of Motion Picture Cameras OC (1650 through 1657)
17. Valve Gear Mechanisms VG (1658 and 1659)
18. Aircraft Landing Gear Mechanisms AL (1660 through 1664)
19. Sorting and Feeding Mechanisms SF (1665 through 1669)
20. Mechanisms of Measuring and Testing Devices M (1670 and 1671)
21. Mechanisms of Other Functional Devices FD (1672 through 1683)

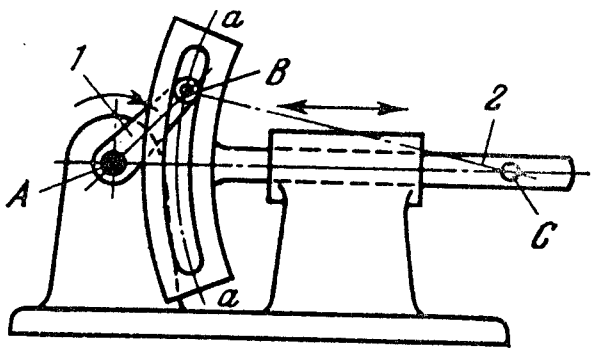
# 1. GENERAL-PURPOSE THREE-LINK MECHANISMS (1475 and 1476)

| 1475 | THREE-BAR SLIDER-CRANK MECHANISM | SC 3L |
|---|---|---|




The lengths of the links comply with the condition: $\overline{DB} = \overline{BC}$. Link *1* carries roller *a* which slides along fixed slot *b-b* whose width equals the diameter of the roller. Point *A* of link *1*, located at the distance $\overline{AB} = \overline{BD}$, moves along straight line *x-x* which is perpendicular to the axis of slot *b-b*. The points of handle *d* describe elliptic paths. The lengths of these paths depend upon the length of slot *b-b*.

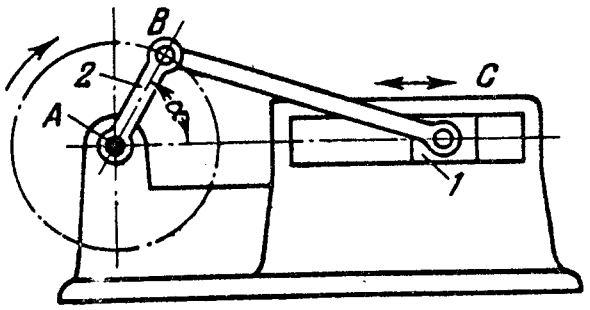
| 1476 | THREE-BAR CIRCULAR-SLOTTED-LINK SLIDER-CRANK MECHANISM (MODIFIED SCOTCH YOKE) | SC 3L |
|---|---|---|




Crank *1* rotates about fixed axis *A*. Roller *B* of crank *1* slides along circular guiding slot *a-a* of radius $\overline{BC}$ and with its centre at point *C* of link *2*. When crank *1* rotates about axis *A*, slotted link *2* reciprocates in fixed guides. The mechanism is equivalent to slider-crank linkage *ABC* in which *AB* is the crank, *BC* is the connecting rod and link *2* is the slider.

## 2. GENERAL-PURPOSE FOUR-LINK MECHANISMS (1477 through 1503)

| 1477 | ALIGNED SLIDER-CRANK MECHANISM | SC 4L |
|---|---|---|




The axis of slider *1* passes through the axis of rotation of crank *2*. Displacement *s* of the slider from its right-hand extreme (dead-centre) position is

$$s = \overline{AB}(1-\cos\alpha)+\overline{BC}\left(1-\sqrt{1-\left(\frac{\overline{AB}}{\overline{BC}}\right)^2\sin^2\alpha}\right)$$

where $\alpha$ is the angle of rotation of the crank. If ratio $\frac{\overline{AB}}{\overline{BC}}$ is sufficiently low then the approximate equation

$$s = r\left[\left(1+\frac{1}{4}\frac{\overline{AB}}{\overline{BC}}\right)-\left(\cos\alpha+\frac{\overline{AB}}{\overline{BC}}\cos 2\alpha\right)\right]$$

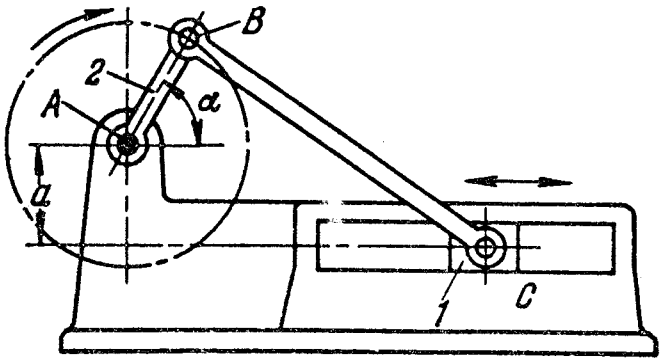
where $r = \overline{AB}$, can be used.
The velocity of point *C* can be determined by the equation

$$v_C = v_B\left(\sin\alpha+\frac{\frac{\overline{AB}}{\overline{BC}}\sin\alpha\cos\alpha}{\sqrt{1-\left(\frac{\overline{AB}}{\overline{BC}}\right)^2\sin^2\alpha}}\right)$$

or

$$v_C = v_B\left(\sin\alpha+\frac{1}{2}\frac{\overline{AB}}{\overline{BC}}\sin 2\alpha\right)$$

where $v_B$ is the velocity of point *B* of crank *2*. The full stroke of slider *1* equals $S = 2\overline{AB}$.




The displacement of slider *1* from its right-hand extreme (dead-centre) position is

$$s = \sqrt{(\overline{AB}+\overline{BC})^2 - a^2} - \overline{AB}\cos\alpha - \overline{BC}\sqrt{1-\left(\frac{\overline{AB}\sin\alpha + a}{\overline{BC}}\right)^2}.$$

The velocity of point $C$ is

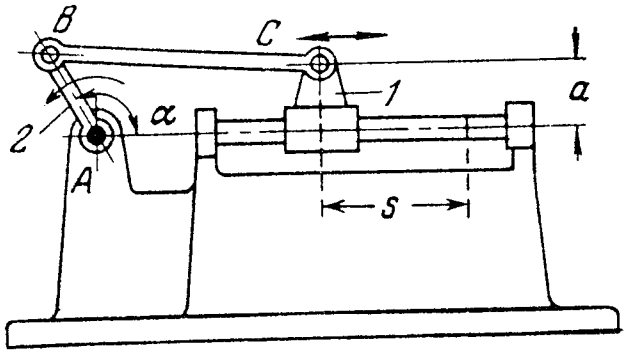
$$v_C = v_B\left[\sin\alpha + \frac{\cos\alpha\,(\overline{AB}\sin\alpha + a)}{\overline{BC}\sqrt{1-\left(\frac{\overline{AB}\sin\alpha + a}{\overline{BC}}\right)^2}}\right]$$

where $v_B$ = velocity of point $B$ of crank *2*
$a$ = offset
$\alpha$ = angle of rotation of crank *2*.

The full stroke of slider *1* equals

$$S = \sqrt{(\overline{BC}+\overline{AB})^2 - a^2} - \sqrt{(\overline{BC}-\overline{AB})^2 - a^2}.$$

| 1479 | OFFSET SLIDER-CRANK MECHANISM | SC 4L |
|---|---|---|




Axis $C$ is located above the axis of rotation $A$ of crank 2. The displacement of slider 1 from its right-hand extreme (dead-centre) position is

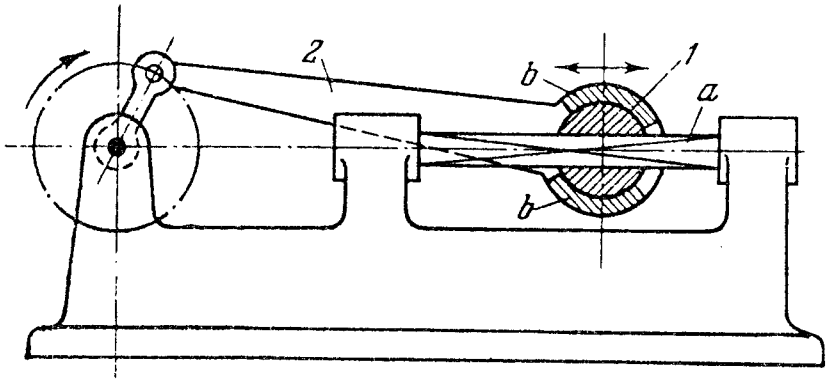
$$s = \sqrt{(\overline{AB}+\overline{BC})^2 - a^2} - \overline{AB}\cos\alpha - \overline{BC}\sqrt{1-\left(\frac{\overline{AB}\sin\alpha - a}{\overline{BC}}\right)^2}.$$

The velocity of point $C$ is

$$v_C = v_B\left[\sin\alpha + \frac{\cos\alpha\,(\overline{AB}\sin\alpha - a)}{\overline{BC}\sqrt{1-\left(\frac{\overline{AB}\sin\alpha - a}{\overline{BC}}\right)^2}}\right]$$

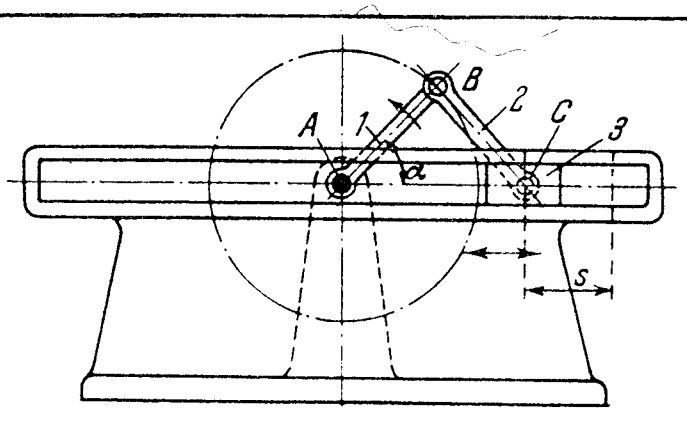
where $v_B$ = velocity of point $B$ of crank 2
$a$ = offset
$\alpha$ = angle of rotation of crank 2.

| 1480 | SLIDER-CRANK MECHANISM WITH A SPHERICAL PIVOT | SC 4L |
|---|---|---|



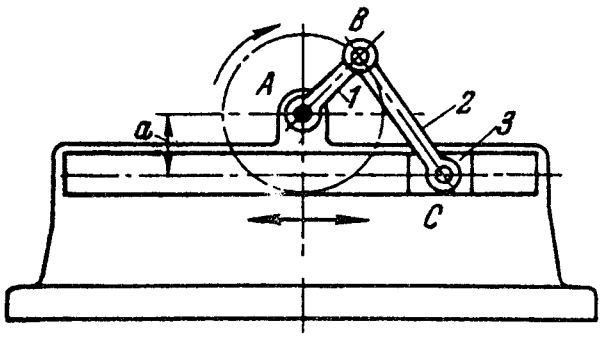

Prismatic guide *a* is rigidly mounted on the base. Slider *1* is a sphere with a prismatic hole fitting guide *a*. Spherical surface *b* of connecting rod *2* fits over spherical slider *1*.

| 1481 | SLIDER-CRANK MECHANISM WITH EQUAL CRANK AND CONNECTING-ROD LENGTHS | SC 4L |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AB} = \overline{BC}$. The motion of the mechanism is uncertain in the position where point $B$ and $A$ coincide. If slider *3* continues moving to the left from this position (point $A$), then the full stroke of slider *3* equals twice the diameter of the circle described by the crank. The slider travels with harmonic motion. The displacement of slider *3* from its extreme right-hand position is $s = 2A\overline{B}(1-\cos\alpha)$. The velocity of point $C$ is $v_C = 2v_B \sin\alpha$, where $v_B$ is the velocity of point $B$ of crank *1* and $\alpha$ is the angle of rotation of crank *1*.

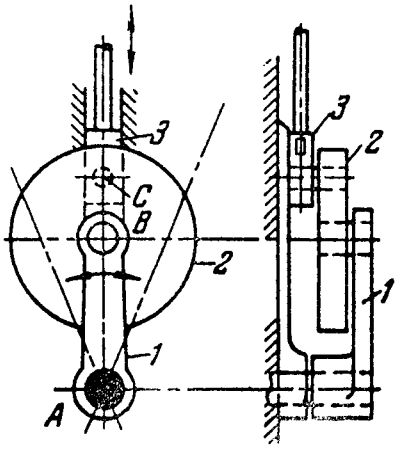
| 1482 | OFFSET SLIDER-CRANK MECHANISM | SC 4L |
|---|---|---|




The lengths of the links comply with the condition: $\overline{BC} = \overline{AB} + a$. In the upper vertical position of crank *1*, points *A*, *B* and *C* lie on a single straight line, and the motion of the mechanism is uncertain. If slider *3* continues moving to the left, then its full stroke will be

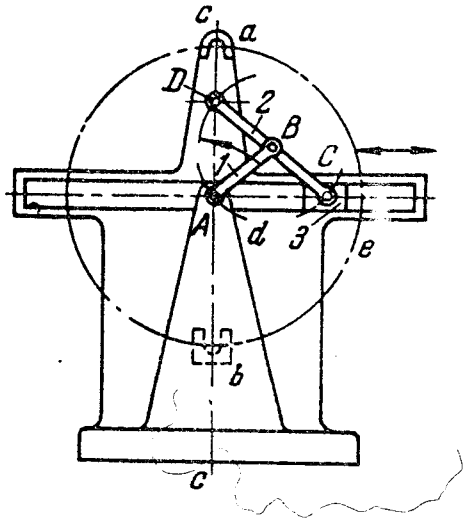
$$S = 4\sqrt{\overline{AB} \times \overline{BC}}.$$

| 1483 | STANNE SLIDER-CRANK MECHANISM | SC 4L |
|---|---|---|



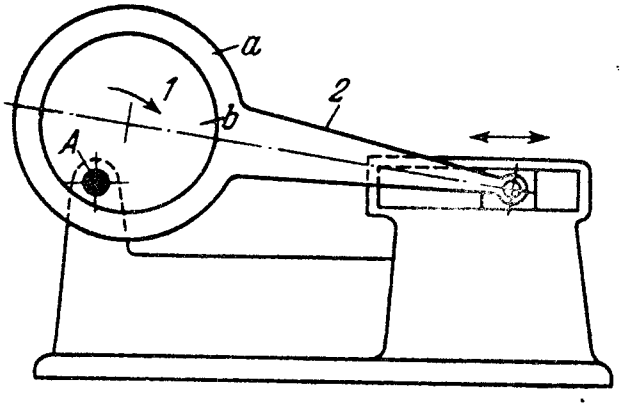

Connecting rod *2* is designed as a flywheel. When link *1* oscillates, slider *3* reciprocates.

| 1484 | SLIDER-CRANK MECHANISM WITH EQUAL CRANK AND CONNECTING-ROD LENGTHS AND WITH A STOP | SC 4L |
|---|---|---|



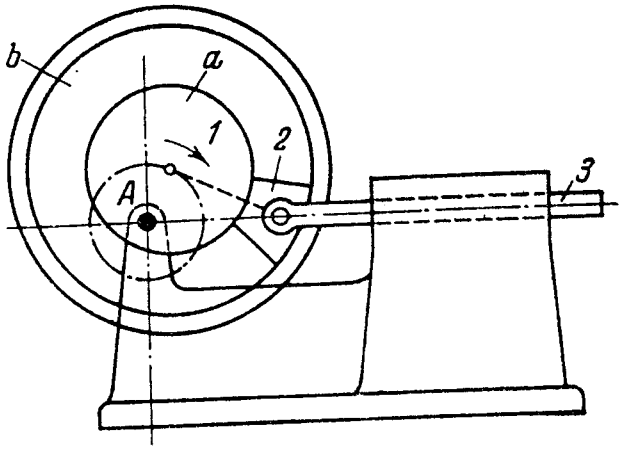

The lengths of the links comply with the condition: $\overline{AB} = \overline{BC} = \overline{BD}$. Point $D$ travels along straight line $c$-$c$. Stops $a$ and $b$ are provided to eliminate uncertainty of motion of the mechanism when it passes through its uncertain (dead-centre) position. The motion of connecting rod *2* can be reproduced by the rolling of circle $d$ without slipping around fixed circle $e$, the radii of the circles being in the proportion $\overline{AB} : \overline{DC}$. The full stroke $S$ of slider *3* is equal to four times the length of crank *1*.

| 1485 | ECCENTRIC-TYPE SLIDER-CRANK MECHANISM | SC 4L |
|---|---|---|



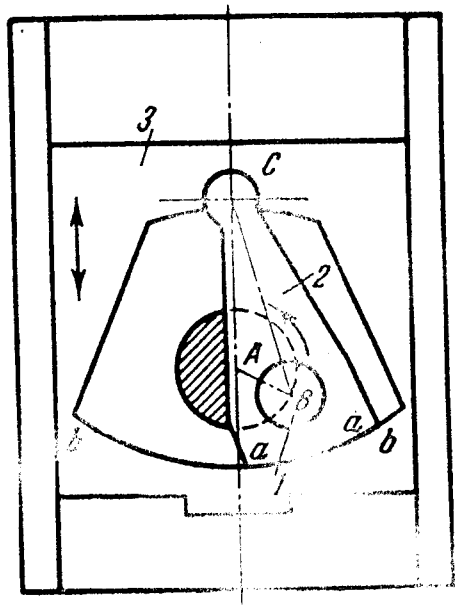

Crank *1* is designed as round eccentric *b* which rotates about fixed axis *A*. Connecting rod *2* has collar *a* encircling eccentric *b*.

| 1486 | ECCENTRIC-TYPE SLIDER-CRANK MECHANISM | SC 4L |
|---|---|---|



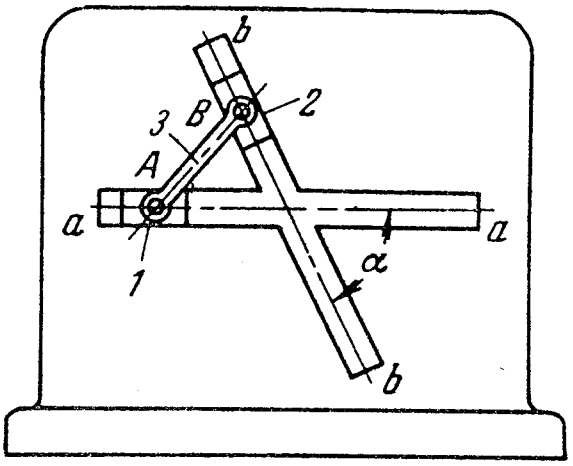

Crank *1* is designed as round eccentric *a*, and the connecting rod as circular slider *2* moving along annular guide *b*. Slider *3*, designed as a rod, reciprocates in fixed guides of the base.

| 1487 | SLIDER-CRANK MECHANISM WITH A CRANKPIN | SC 4L |
|---|---|---|



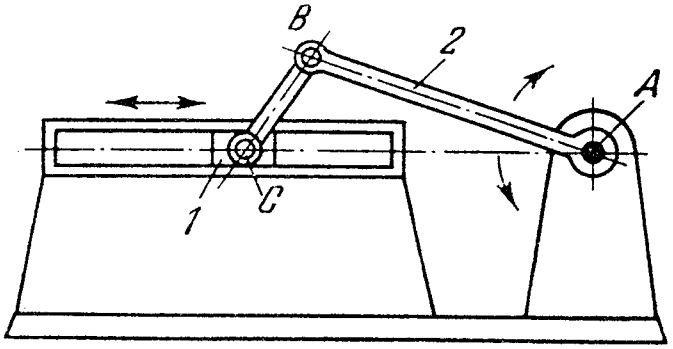

Connecting rod *2* is connected by turning pair *C* to slider *3*. At its other end connecting rod *2* has circular arc *a-a* which slides along circular recess *b-b* of slider *3*. The centre of both arcs is at point *C*. When crankpin *1* rotates about fixed axis *A*, slider *3* is reciprocated in fixed guides by connecting rod *2*.

| 1488 | SLIDER-CONNECTING ROD MECHANISM WITH TWO SLIDERS | SC 4L |
|---|---|---|



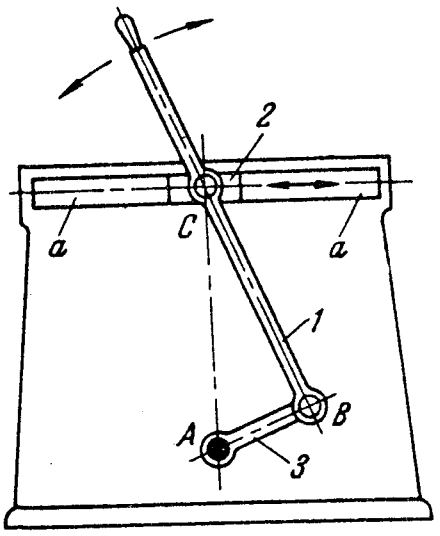

Sliders *1* and *2* are connected by turning pairs *A* and *B* to connecting rod *3* and reciprocate in fixed guides *a-a* and *b-b*. There may be any angle $\alpha$ between the axes of the guides.

| 1489 | SLIDER-DRIVEN SLIDER-ROCKER ARM MECHANISM | SC 4L |
|---|---|---|



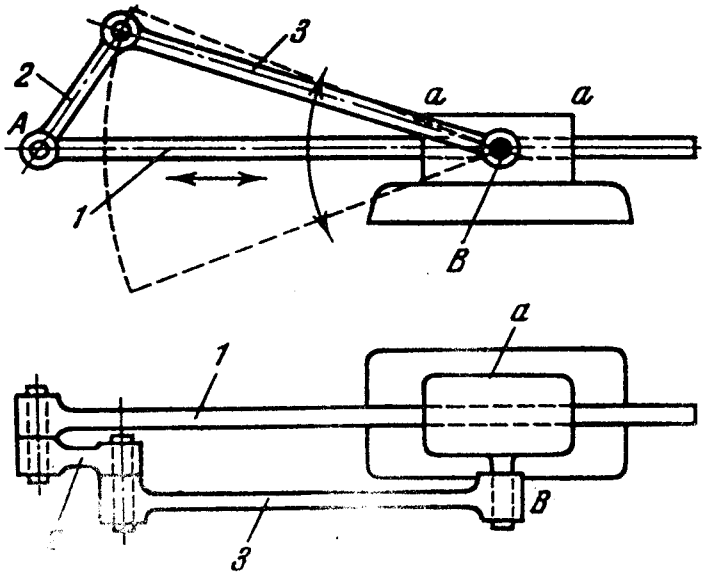

The lengths of the links comply with the condition: $\overline{AB} > \overline{BC}$. When slider *1* reciprocates, rocker arm *2* oscillates about fixed axis *A*.

| 1490 | CONNECTING-ROD-DRIVEN SLIDER-CRANK MECHANISM | SC 4L |
|---|---|---|



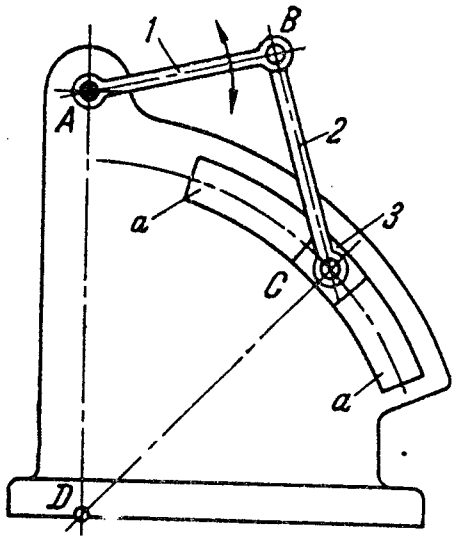

Connecting rod *1* is connected by turning pairs *C* and *B* to slider *2* and to crank *3* which rotates about fixed axis *A*. Slider *2* moves along fixed guides *a-a*. When connecting rod *1* oscillates, crank *3* rotates about axis *A*.

| 1491 | SLIDER-DRIVEN SLIDER-CRANK MECHANISM | SC 4L |
|---|---|---|



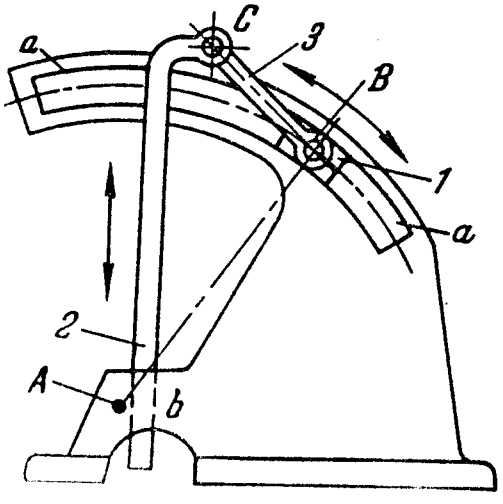

Link *1* slides in fixed guides *a-a*. Link *3* turns about fixed axis *B*. The reciprocating motion of link *1* is converted by link *2* into oscillating motion of link *3*. Link *2* has a complex plane-parallel motion.

| 1492 | CIRCULAR-GUIDE SLIDER-ROCKER ARM MECHANISM | SC 4L |
|---|---|---|



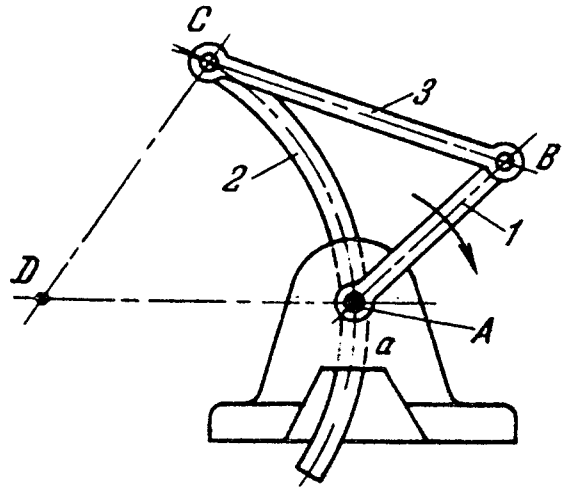

The lengths of the links comply with the conditions: $\overline{AB} + \overline{BC} < \overline{AD} + \overline{DC}$ and $AB < \overline{BC} < \overline{CD} < \overline{AD}$. Link *3* is a circular slider moving along circular guides *a-a* of radius $\overline{DC}$ and with the centre at point *D*. When link *1* oscillates about fixed axis *A*, slider *3* oscillates in guides *a-a*. The mechanism is equivalent to four-bar double-swing linkage *ABCD* in which *AB* and *CD* are rocker arms and *BC* is the connecting rod.

| 1493 | CIRCULAR-GUIDE SLIDER-ROCKER ARM MECHANISM | SC 4L |
|---|---|---|



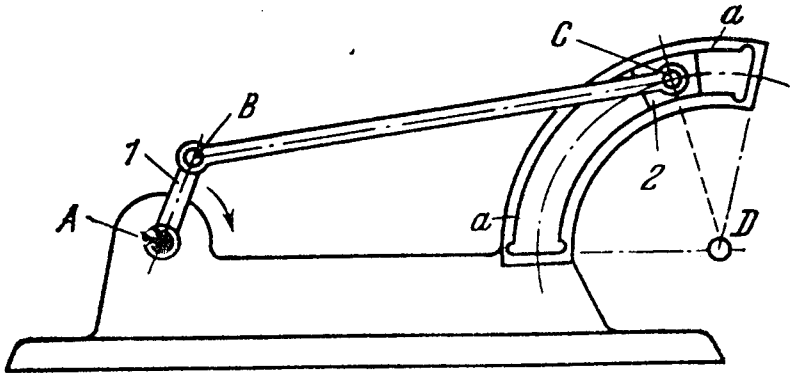

Circular slider *1* moves along circular guides *a-a* of radius $\overline{AB}$ and with the centre at point *A*. Connecting rod *3* is connected by turning pairs *B* and *C* to sliders *1* and *2*. Slider *2* moves in fixed guide *b*. When slider *1* oscillates along guides *a-a*, slider *2* reciprocates. The mechanism is equivalent to slider-rocker arm linkage *ABC* in which *AB* is the crank.

| 1494 | SLIDER-CRANK MECHANISM WITH A CIRCULAR SLIDER | SC 4L |
|---|---|---|



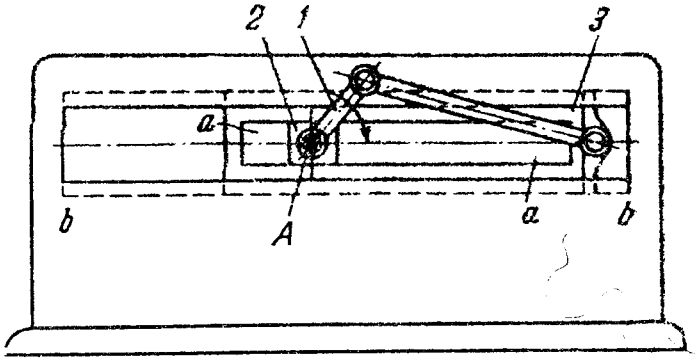

Crank *1* rotates about fixed axis *A*. Connecting rod *3* is connected by turning pairs *B* and *C* to crank *1* and to circular slider *2* which moves in circular guide *a* of radius $\overline{DA}$ and with its centre at point *D*. The mechanism is equivalent to four-bar linkage *ABCD*.

| 1495 | CIRCULAR-GUIDE SLIDER-CRANK MECHANISM | SC 4L |
|---|---|---|



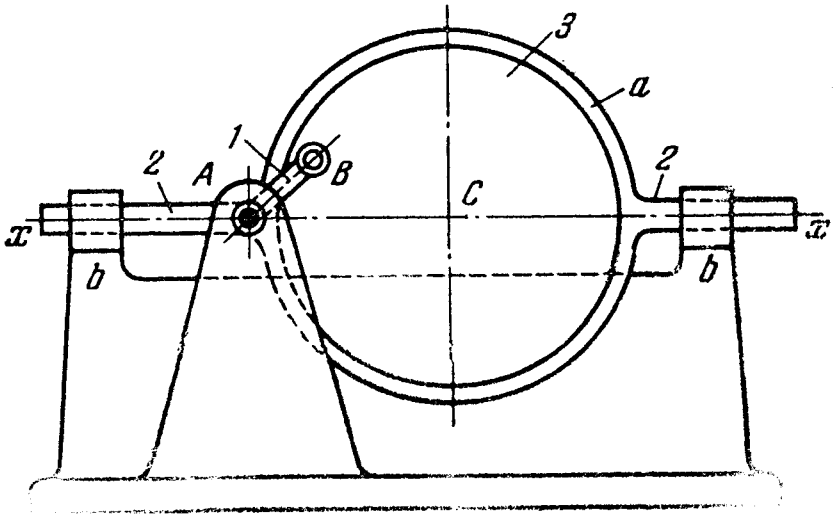

The lengths of the links comply with the conditions: $\overline{AB} + \overline{BC} < \overline{AD} + \overline{CD}$ and $\overline{AB} < \overline{CD} < \overline{BC} < \overline{AD}$. Link *2* is a circular slider moving along circular guides *a-a* of radius $\overline{DC}$ and with the centre at point *D*. When crank *1* rotates about fixed axis *A*, link *2* oscillates in guides *a-a*. The mechanism is equivalent to four-bar crank and rocker arm linkage *ABCD* in which *AB* is the crank, *BC* is the connecting rod and *CD* is the rocker arm.

| 1496 | MOVING-GUIDE SLIDER-CRANK MECHANISM | SC 4L |
|---|---|---|



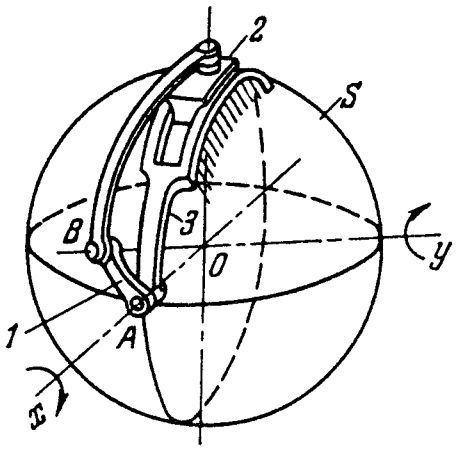

Crank *1* rotates about fixed axis *A*. Slider *3* moves along fixed guides *b-b* and has slot *a-a* which moves along fixed slider *2*. When crank *1* rotates about axis *A*, guide *3* reciprocates in the horizontal direction.

| 1497 | SLIDER-CRANK MECHANISM WITH COLLAR AND DISK | SC 4L |
|---|---|---|



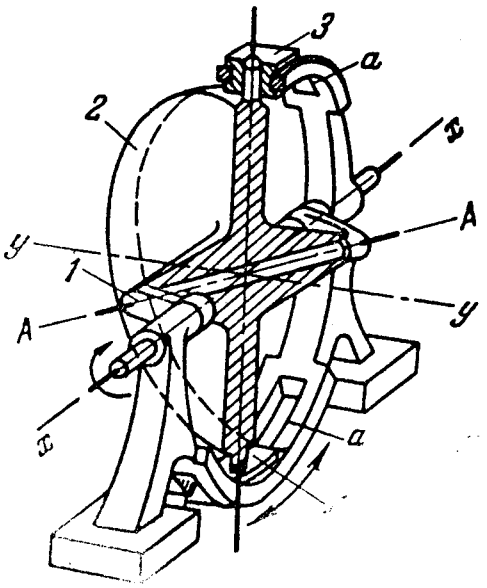

Link *2* is designed as collar *a* encircling disk *3* which has its centre at point *C*. When crank *1* rotates about fixed axis *A*, link *2* reciprocates along axis *x-x* in fixed guides *b-b*. The mechanism is equivalent to slider-crank linkage *ABC*.

| 1498 | SPHERICAL SLIDER-CRANK MECHANISM | SC 4L |
|---|---|---|



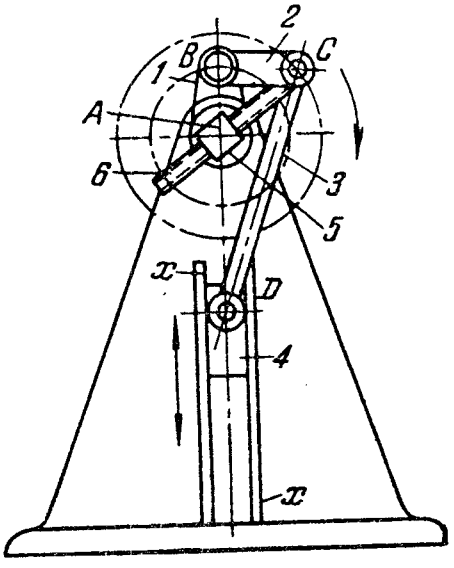

Fixed guide *3* is designed along an arc of a great circle of sphere *S*. The axis of pin *B* passes through point *O*, the centre of the sphere. Crank *1* rotates and slider *2* oscillates about axes *x* and *y* which are perpendicular to each other and intersect at point *O*.

| 1499 | SPHERICAL SLIDER-CRANK MECHANISM | SC 4L |
|---|---|---|



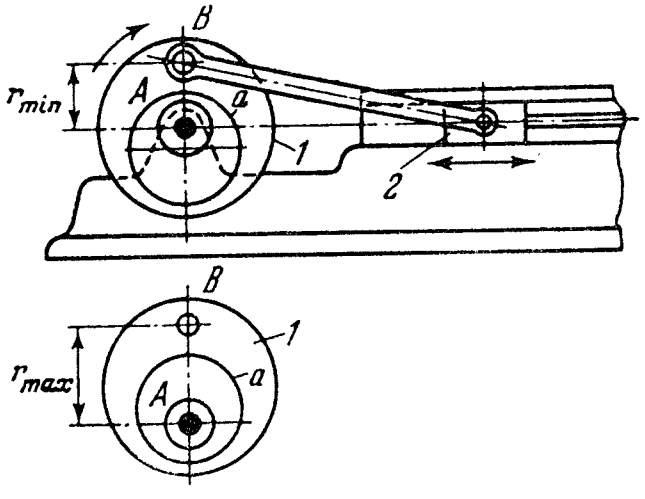

Crank *1* rotates about fixed axis *x-x* and is connected by turning pair *A-A* to link *2* which, in turn, is connected by turning pairs to circular sliders *3* and *4*. Sliders *3* and *4* move along circular guides *a*. When crank *1* rotates about axis *x-x*, sliders *3* and *4* oscillate in circular guides *a* of the base about axis *y-y* under the condition that the axes of all the kinematic pairs intersect in a single point.

| 1500 | SLIDER-CRANK MECHANISM WITH CRANK LENGTH ADJUSTMENT | SC 4L |
|---|---|---|



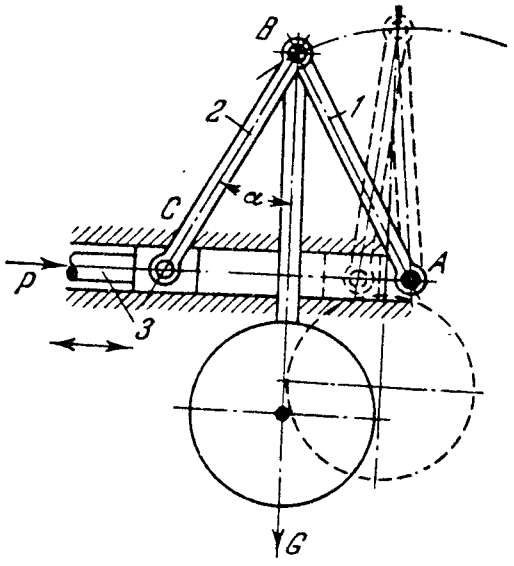

Five-bar linkage *ABCD*, consisting of links *1*, *2* and *3* and slider *4*, has two degrees of freedom. Slider *4* moves along fixed guides *x-x*. Links *5* and *6* are connected by a screw pair. Distance $\overline{AC}$ can be varied by setting link *6* in the required position with respect to link *5*. When link *5* is connected by turning pair *C* to link *2*, five-bar linkage *ABCD* is converted into slider-crank linkage *ACD* having only one degree of freedom.

| 1501 | SLIDER-CRANK MECHANISM WITH CRANK LENGTH ADJUSTMENT | SC 4L |
|---|---|---|




Link *1* has a round hole of a diameter equal to that of eccentric *a*. When eccentric *a* is turned about fixed axis *A* in disk *1* and is clamped in the required position, the length of crank *AB* can be varied from $r_{min}$ to $r_{max}$, thereby varying the stroke of slider *2*.

| 1502 | SLIDER-CRANK MECHANISM WITH A PENDULUM SUSPENSION | SC 4L |
|---|---|---|

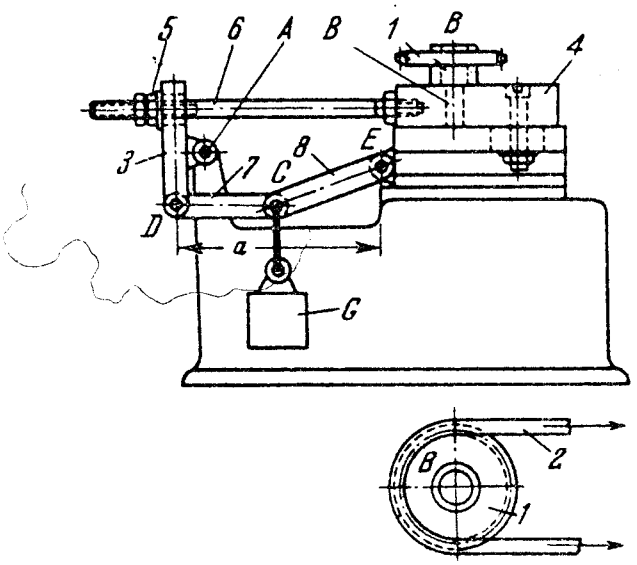



The lengths of the links comply with the condition: $\overline{AB} = \overline{BC}$. Freely suspended at point $B$ is a pendulum with a bob of weight $G$. Due to this weight, slider *3* is displaced in its guides from the extreme right-hand position, shown by the dash lines, to the left, overcoming force $P$ which equals

$$P = \frac{G}{2} \tan \alpha$$

where $\alpha$ is one half of the angle between links *1* and *2*.

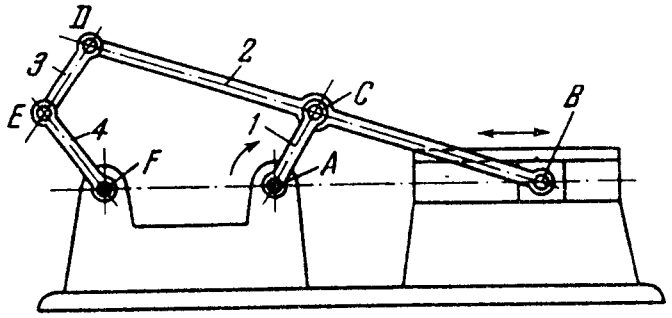
| 1503 | SLIDER-CRANK MECHANISM | SC 4L |
|---|---|---|




Link *3* turns about fixed axis *A*. Link *7* is connected by turning pairs *D* and *C* to links *3* and *8*. Link *8* is connected by turning pair *E* to plate *4* on which chain sprocket *1* is mounted. Weight *G* is suspended from point *C*. The tension of chain *2* is applied to sprocket *1* and is counterbalanced by weight *G*. When the tension of chain *2* is reduced, weight *G* reduces the distance *a*, turning lever *3* about axis *A* through a certain angle. This displaces plate *4* with axis *B* of chain sprocket *1* to the left by an amount that takes up the slack in the chain. Nut *5* on tie-rod *6* provides for regulation of the chain tension.

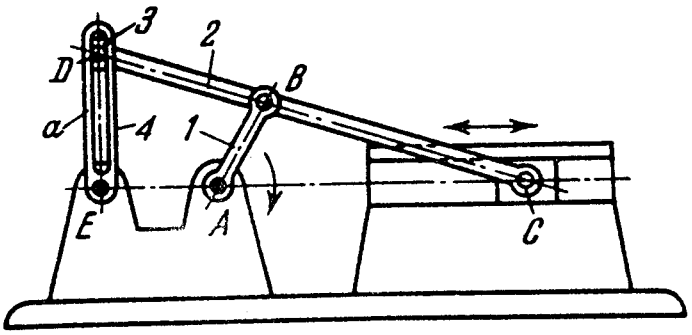
## 3. GENERAL-PURPOSE SIX-LINK MECHANISMS (1504 through 1528)

| 1504 | SLIDER-CRANK MECHANISM WITH AN ATTACHED DOUBLE GUIDING ELEMENT | SC 6L |
|---|---|---|




Link *3* is attached through turning pair *D* to connecting rod *2* of slider-crank linkage *ABC*. Link *3* is connected by turning pair *E* to link *4* which turns about fixed axis *F*. When crank *1* rotates about fixed axis *A*, point *D* of connecting rod *2* describes a connecting-rod curve. Depending upon the lengths of links *2*, *3* and *4*, link *4* either makes complete revolutions about axis *F* or oscillates about this axis.

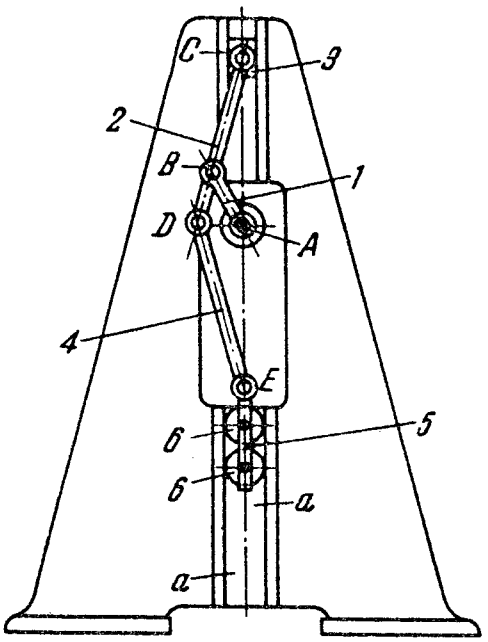
| 1505 | SLIDER-CRANK MECHANISM WITH AN ATTACHED SLOTTED LINK | SC 6L |
|---|---|---|




Slider *3* moves along slot *a* of slotted link *4* and is attached by turning pair *D* to connecting rod *2* of slider-crank linkage *ABC*. Slotted link *4* turns about fixed axis *E*. When crank *1* rotates about fixed axis *A*, point *D* of connecting rod *2* describes a connecting-rod curve. If point *E* is within the area circumscribed by point *D*, slotted link *4* makes complete revolutions about axis *E*. If not, then link *4* only oscillates about axis *E*.

## 1506 SLIDER-CRANK MECHANISM WITH ATTACHED CONNECTING ROD AND SLIDER

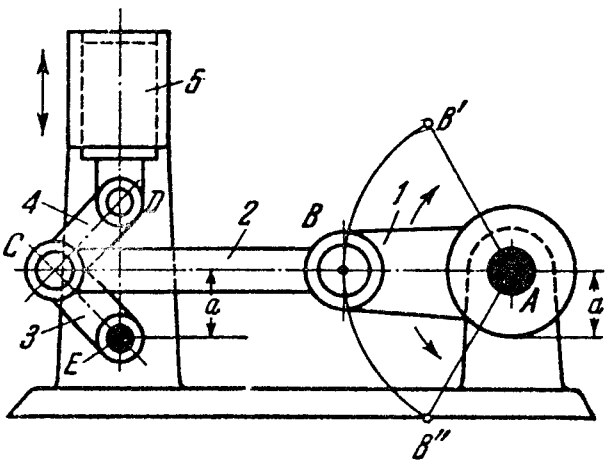
SC 6L




Connecting rod *4* is attached by turning pair *D* to connecting rod *2* of slider-crank linkage *ABC*. Connecting rod *4* drives link *5* which is designed as a truck with wheels *6* rolling along guides *a-a*. At positions of slider *3* near to its extreme upper position, a portion of the path of point *D* can be approximated by the arc of a circle of radius $\overline{DE}$. When crank *1* rotates about fixed axis *A*, slider *3* and truck *5* reciprocate. The time that truck *5* is in its upper extreme position is longer than for slider *3*.

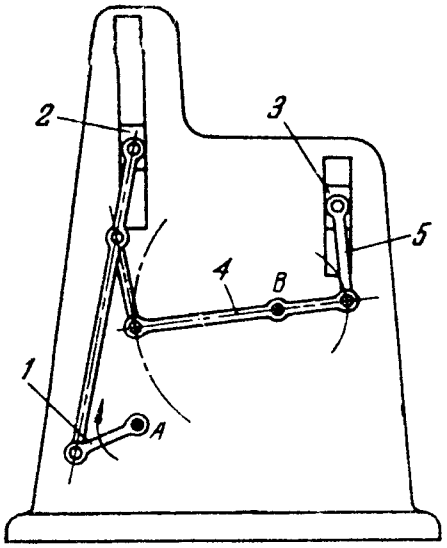
## 1507 SLIDER-CRANK MECHANISM WITH DOUBLED SLIDER STROKE

SC 6L



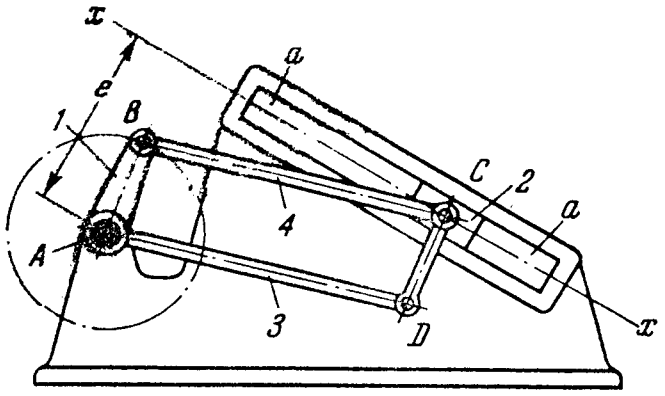

The lengths of the links comply with the condition: $\overline{EC} = \overline{CD}$. Link *1* oscillates within angle $B'AB''$ about fixed axis *A*. Oscillation of link *1* is converted by links *2*, *3* and *4* into reciprocation of slider *5*. During one complete oscillation of link *1*, slider *5* accomplishes two complete cycles of motion. The displacement *s* of point *D* of the slider from its extreme lower position, shown in the drawing, to its extreme upper position equals $s = 2(\overline{CD} - a)$.

| 1508 | SLIDER-CRANK MECHANISM WITH TWO SLIDERS | SC 6L |
|---|---|---|



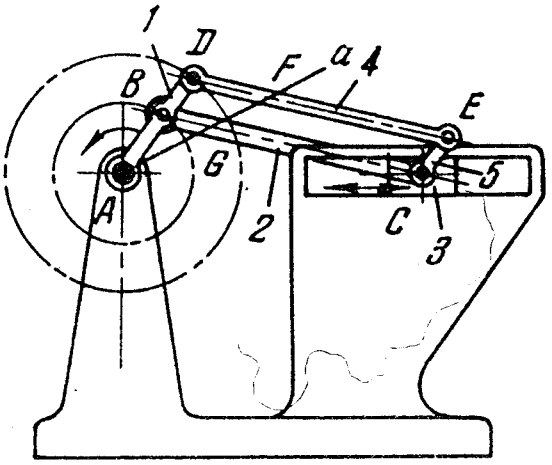

When crank *1* rotates about fixed axis *A*, slider *2* reciprocates. Reciprocation is transmitted to slider *3* through lever *4*, turning about fixed axis *B*, and connecting rod *5*.

| 1509 | OFFSET SLIDER-CRANK MECHANISM WITH A PARALLELOGRAM | SC 6L |
|---|---|---|




**The lengths** of the links comply with the conditions: $\overline{AB} = \overline{CD}$ **and** $\overline{BC} = \overline{AD}$, i.e. figure *ABCD* is a parallelogram. Slider *2* moves along fixed guides *a-a* whose axis *x-x* is at a distance of *e* from point *A*. This is the offset of the mechanism. When crank *1* rotates about fixed axis *A*, slider *2* reciprocates along axis *x-x* and **link** *3* oscillates about axis *A*, always remaining parallel to connecting rod *4*.

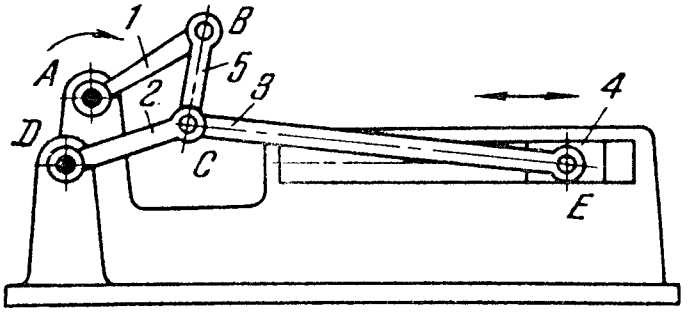
| 1510 | SLIDER-CRANK MECHANISM WITH AN ATTACHED PANTOGRAPH | SC 6L |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{BD} = \overline{CE}$ and $\overline{DE} = \overline{BC}$. Thus figure $BDEC$ is a parallelogram. When crank *1* rotates about fixed axis $A$, slider *3* reciprocates. If arbitrary ray $Aa$ is drawn from point $A$, then points $G$ and $F$, lying on the axes of links *2* and *4*, will describe similar paths with a similarity factor

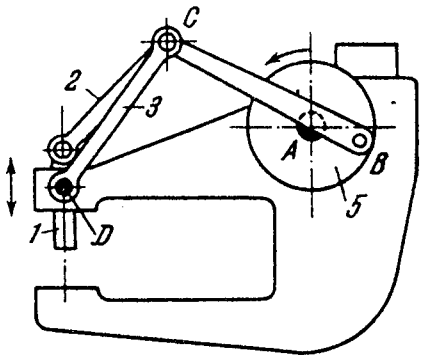
$$k = \frac{\overline{AD}}{\overline{AB}}.$$

| 1511 | SIX-BAR SLIDER-CRANK MECHANISM | SC 6L |
|---|---|---|



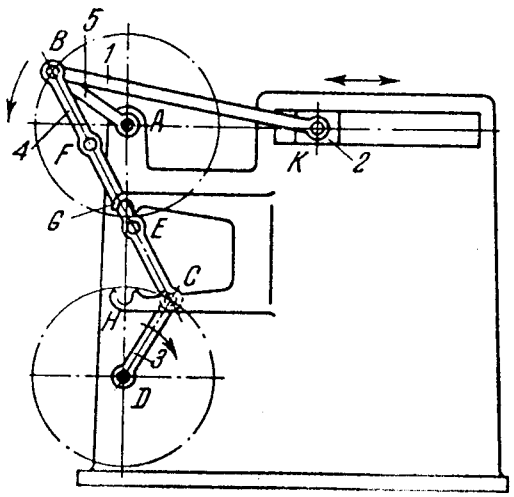

Connecting rod *3* is attached by turning pair $C$ to four-bar linkage $ABCD$ and is connected by turning pair $E$ to slider *4*. The lengths of the links comply with the conditions $\overline{AB} + \overline{AD} < \overline{BC} + \overline{DC}$, so that links *1* and *2* are both cranks. When crank *1* rotates about fixed axis $A$ at uniform velocity, crank *2* rotates about fixed axis $D$ at nonuniform velocity, and the times for the forward and return strokes of slider *4* differ.

| 1512 | SIX-BAR SLIDER-CRANK MECHANISM | SC, 6L |
|---|---|---|



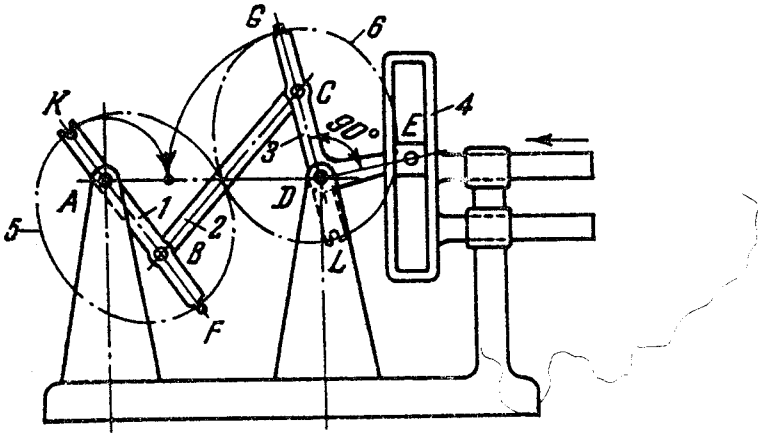

Slider *1* is driven by link *2* which is attached through turning pair *C* to rocker arm *3* of four-bar linkage *ABCD*. When crank *5* rotates about fixed axis *A*, rocker arm *3* oscillates about fixed axis *D* and slider *1* reciprocates.

| 1513 | CROSSED-CRANK MECHANISM WITH ATTACHED CONNECTING ROD AND SLIDER | SC 6L |
|---|---|---|



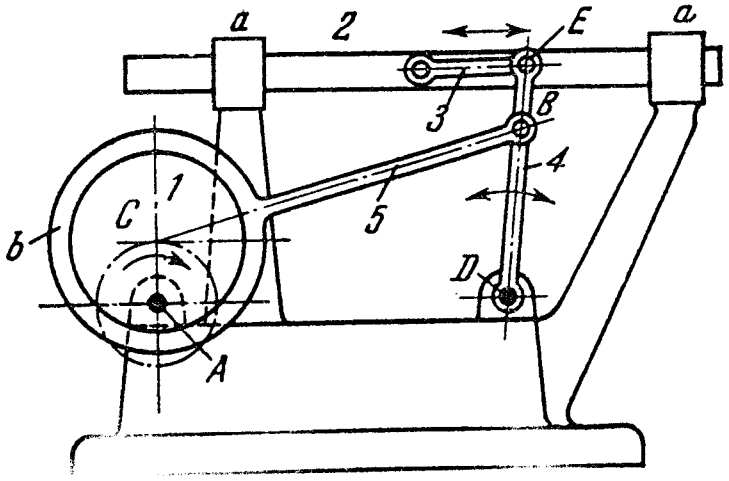

The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$ and $\overline{BC} = \overline{AD}$. Connecting rod *1* is attached through turning pair *B* to crossed-crank linkage *ABCD*. Connecting rod *1* reciprocates slider *2*. When crank *3* rotates at uniform velocity about fixed axis *D*, crank *5* rotates about fixed axis *A* at nonuniform velocity, transmitting complex motion to slider *2*. Uncertainty of motion of crossed-crank linkage *ABCD* in its extreme (dead centre) positions is eliminated by the provision of pins *F* and *E* on link *4* that enter safety stops *G* and *H*.

| 1514 | CROSSED-CRANK MECHANISM WITH AN ATTACHED TRANSLATIONAL SLIDER | SC 6L |
|---|---|---|



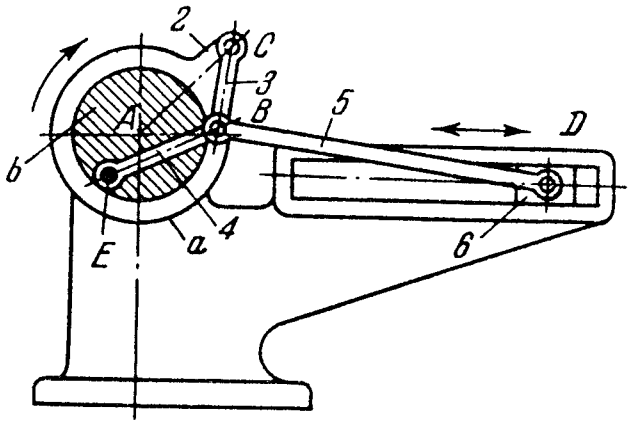

The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$ and $\overline{BC} = \overline{AD}$. The same kind of motion can be transmitted to slider *4* by crossed-crank linkage *ABCD* as by elliptical gears *5* and *6*. Points *A*, *B*, *C* and *D* should be the foci of ellipses *5* and *6*. Uncertainty of motion of crossed-crank linkage *ABCD* in its extreme (dead centre) positions is eliminated by the provision of pins *F* and *G* on links *1* and *3* that enter the corresponding slots, *L* and *K*, of these links.

| 1515 | ECCENTRIC-TYPE SLIDER-ROCKER ARM MECHANISM | SC 6L |
|---|---|---|



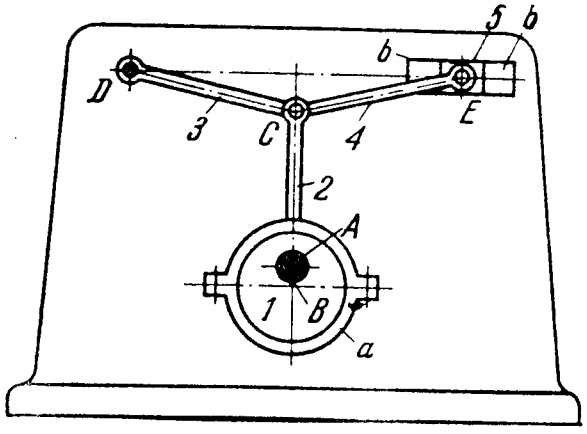

Slider 2 is reciprocated in fixed guides *a-a* by intermediate link *3* which is connected by turning pair *E* to rocker arm *4* of four-bar linkage *ACBD*. The crank of the linkage is designed as eccentric *1* rotating about fixed axis *A*. Connecting rod *5* has collar *b* encircling eccentric *1*.

| 1516 | ECCENTRIC-TYPE SLIDER-CRANK MECHANISM | SC 6L |
|---|---|---|




Link *2* has collar *a* encircling fixed eccentric *b* which has its centre at point *A*. Link *3* is connected by turning pairs *B* to connecting rod *5* and crank *4* of slider-crank linkage *EBD*. When link *2* rotates at uniform velocity about axis *A*, link *4* rotates about fixed axis *E* at nonuniform velocity, transmitting motion to slider *6* with different times for the forward and return strokes.

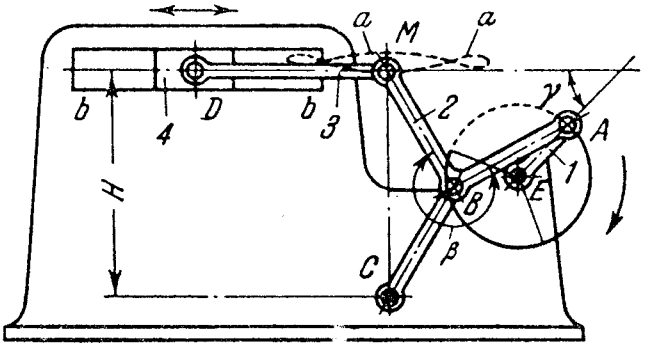
| 1517 | ECCENTRIC-TYPE SLIDER-ROCKER ARM MECHANISM (TOGGLE MECHANISM) | SC 6L |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AB} = 1$ and $\overline{BC} = \overline{CD} = \overline{CE} = 9$. Connecting rod *2* has collar *a* encircling eccentric *1* which rotates about fixed axis *A*. Connecting rod *2* is connected by turning pair *C* to rocker arm *3*. Added to four-bar linkage *ABCD* is connecting rod *4* which, in turn, is connected by turning pair *E* to slider *5*. Slider *5* moves along fixed guides *b-b* and has a short stroke enabling it to overcome a large resistance with a small driving force.

## 1518 CHEBYSHEV SLIDER-ROCKER ARM QUICK-RETURN MECHANISM

SC 6L

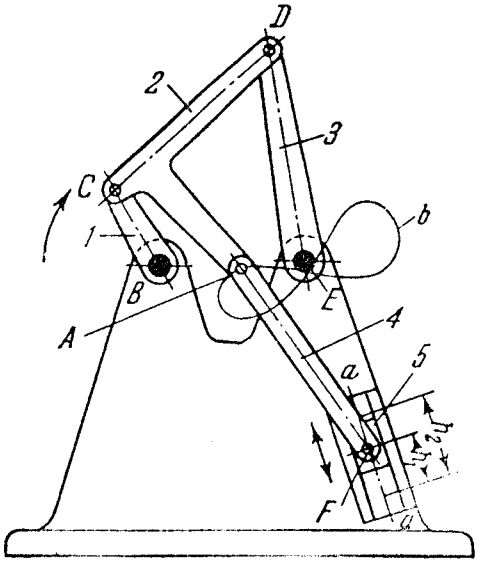



The lengths of the links comply with the conditions: $\overline{AB} = \overline{BC} = \overline{BM} = 1$, $\overline{AE} = 0.55$, $\overline{CE} = 1.38$, $\angle ABM = \beta = 267°$, $\gamma = 43.5°$, $\overline{MD} = 1.5$ and $H = 1.79$. Point $M$ of connecting rod *2* of four-bar linkage $EABC$ describes connecting-rod curve *a-a*. Link *3* is connected by turning pairs $M$ and $D$ to connecting rod *2* and slider *4* which moves along fixed guides *b-b*. The time ratio $k$ of the forward to the return stroke of slider *4*, at constant angular velocity of crank *1* rotating about fixed axis $E$, is

$$k \cong 5/3.$$

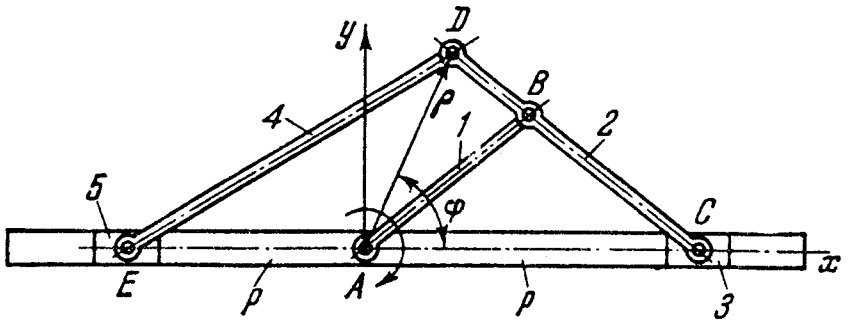
## 1519 SLIDER-CONNECTING ROD MECHANISM WITH TWO DOUBLE STROKES OF THE SLIDER

SC 6L




Connecting rod *4* is connected by turning pair $A$ to link *2* of four-bar linkage $BCDE$ and by turning pair $F$ to slider *5* which moves along fixed guides *a-a*. Point $A$ of link *2* describes connecting-rod curve *b* which is self-intersecting. As a result, slider *5* has two double strokes of different length, $h_1$ and $h_2$, to each complete revolution of cranks *1* and *3* about fixed axes $B$ and $E$.

| 1520 | SIX-BAR MECHANISM WITH AN ELLIPTIC VARIABLE-LENGTH CRANK | SC 6L |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AB} = \overline{BC}$. Link *1* rotates about fixed axis *A* and is connected by turning pair *B* to link *2*. Link *2* is connected by turning pairs *D* and *C* to link *4* and to slider *3* which moves along fixed guides *p-p*. Link *4* is connected by turning pair *E* to slider *5* which moves along guides *p-p*. Point *D* describes an ellipse with its centre at point *A* and with the equation

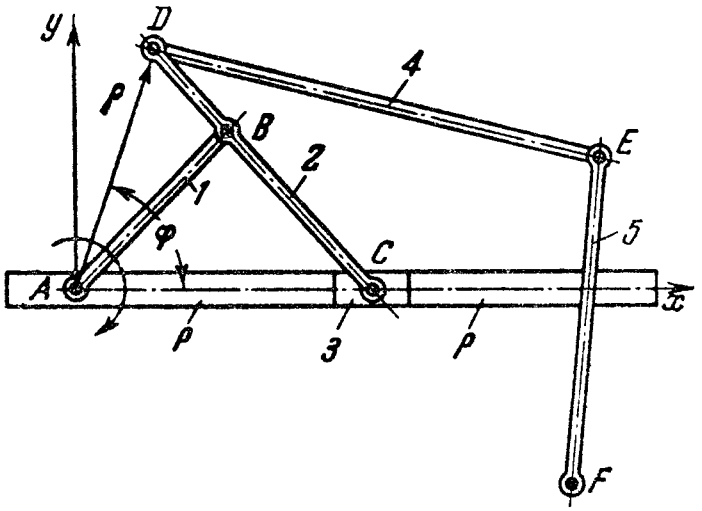
$$\frac{x^2}{(m-n)^2}+\frac{y^2}{(m+n)^2}=1$$

where $m = \overline{AB}$ and $n = \overline{BD}$. Variable vector $\boldsymbol{\rho} = \overline{AD}$ can be regarded as the crank of slider-crank linkage *ADE* with the variable length $\overline{AD}$ of the conventional crank equal to

$$\overline{AD}=(m^2-n^2)\sqrt{\frac{1}{m^2+n^2+2mn\cos 2\varphi}}$$

where $\varphi$ is the angle between vector $\boldsymbol{\rho}$ and axis *Ax*.

| 1521 | SIX-BAR MECHANISM WITH AN ELLIPTIC VARIABLE-LENGTH CRANK | SC 6L |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AB} = \overline{BC}$. Link *1* rotates about fixed axis *A* and is connected by turning pair *B* to link *2*. Link *2* is connected by turning pairs *D* and *C* to link *4* and to slider *3* which moves along fixed guides *p-p*. Link *4* is connected by turning pair *E* to link *5* which turns about fixed axis *F*. Point *D* describes an ellipse with its centre at point *A* and with the equation

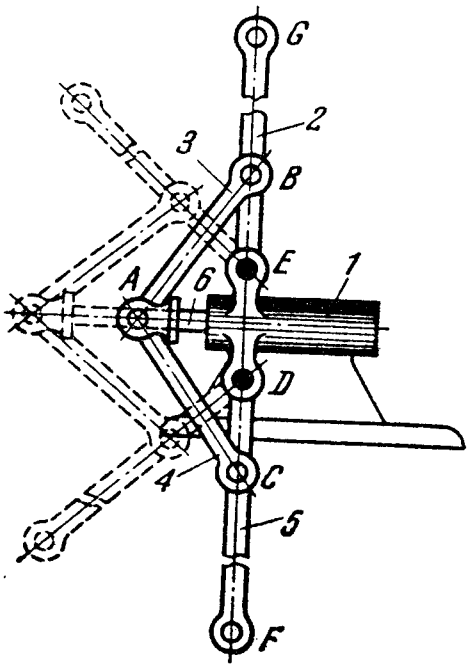
$$\frac{x^2}{(m-n)^2}+\frac{y^2}{(m+n)^2}=1$$

where $m = \overline{AB}$ and $n = \overline{BD}$. Variable vector $\boldsymbol{\rho} = \overline{AD}$ can be regarded as the crank of four-bar linkage *ADEF* with the variable length $\overline{AD}$ of the conventional crank equal to

$$\overline{AD}=(m^2-n^2)\sqrt{\frac{1}{m^2+n^2+2mn\cos 2\varphi}}$$

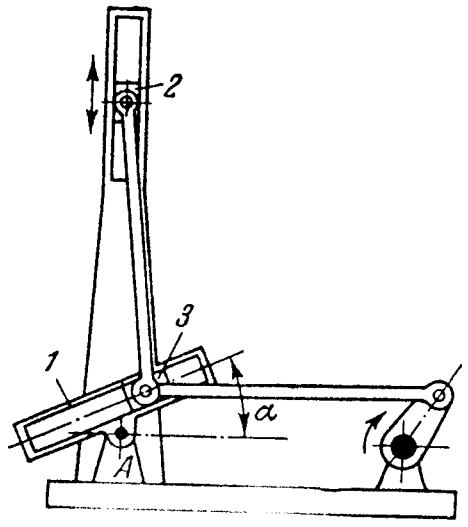
where $\varphi$ is the angle between vector $\boldsymbol{\rho}$ and axis $Ax$.

| 1522 | SLIDER-CRANK FOLDING-BRACE MECHANISM | SC 6L |
|---|---|---|



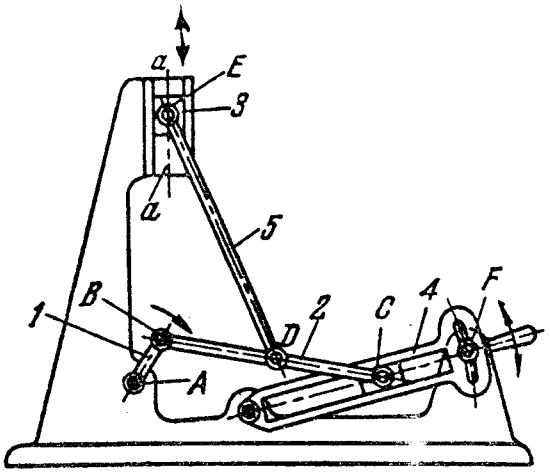

The lengths of the links comply with the conditions: $\overline{BE} = \overline{CD}$ and $\overline{AB} = \overline{AC}$. When piston rod *6* moves along the axis of fixed cylinder *1*, links *2* and *5* turn about fixed axes *E* and *D*, taking the positions shown by the dash lines. The angles of rotation of links *2* and *5* are equal.

| 1523 | SLIDER-CRANK MECHANISM WITH ADJUSTABLE SLIDER STROKES | SC 6L |
|---|---|---|



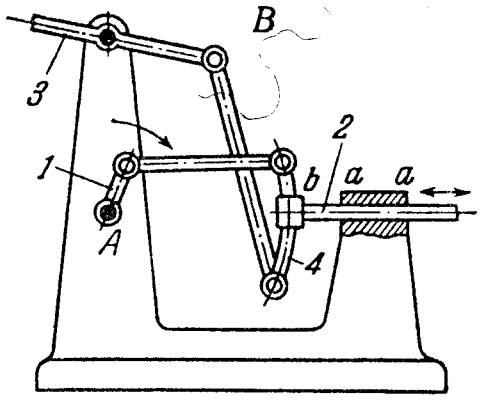

Guiding member *1* can be adjusted about fixed axis *A* and clamped at various angles $\alpha$ to the horizontal. This varies the kind of motion of sliders *2* and *3*.

| 1524 | SLIDER-CRANK MECHANISM WITH ADJUSTABLE ATTACHED SLIDER STROKES | SC 6L |
|---|---|---|



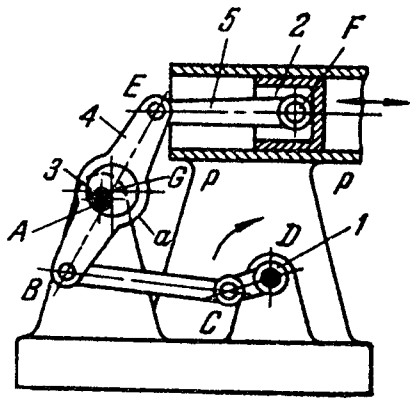

Connecting rod *5* drives slider *3* and is attached by turning pair *D* to connecting rod *2* of slider-crank linkage *ABC*. When crank *1* rotates about fixed axis *A*, slider *3* reciprocates along fixed guides *a-a*. The stroke of slider *3* can be varied by turning guiding link *4* and clamping it at point *F*.

| 1525 | SLIDER-CRANK MECHANISM WITH DRIVEN-LINK STROKE ADJUSTMENT | SC 6L |
|---|---|---|



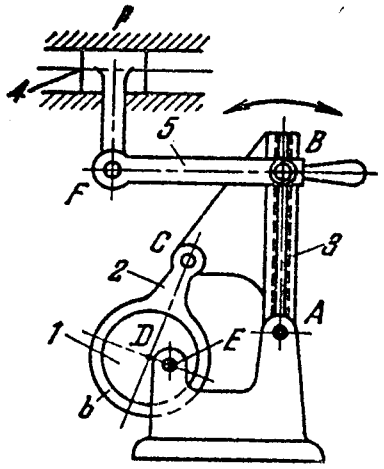

Link *4* whose axis is a circular arc slides in circular guide *b* of link *2*. When driving crank *1* rotates about fixed axis *A*, link *2* reciprocates in fixed guides *a-a*. The stroke of slider *2* is varied by changing the position of pivot *B*. This is accomplished by rigidly clamping lever *3* in the required position. The design of the clamp for lever *3* is not shown.

## 1526 SLIDER-CRANK MECHANISM WITH DRIVEN-LINK STROKE ADJUSTMENT — SC 6L



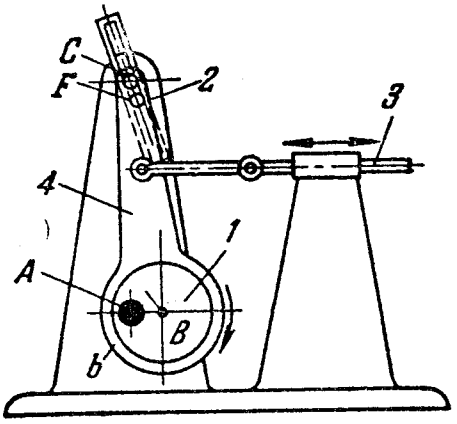

Rocker arm *4* of four-bar linkage *GBCD* has collar *a* encircling fixed round eccentric *3*. Rocker arm *4* is connected by turning pair *E* to connecting rod *5* which, in turn, is connected by turning pair *F* to piston *2*. Piston *2* slides in fixed guides *p-p*. When crank *1* rotates about fixed axis *D*, piston *2* reciprocates. The stroke of piston *2* is varied by turning eccentric *3* and clamping it rigidly at the required position on axis *A*.

## 1527 SLIDER-ROCKER ARM MECHANISM WITH DRIVEN-LINK STROKE ADJUSTMENT — SC 6L




Connecting rod *2* of four-bar linkage *ACDE* has collar *b* encircling eccentric *1* which rotates about fixed axis *E*. Connecting rod *5* is connected by turning pairs *B* and *F* to rocker arm *3*, turning about fixed axis *A*, and to slider *4*, moving along fixed guide *p*. When eccentric *1* rotates about axis *E*, slider *4* reciprocates. The slider stroke is varied by changing the length, $\overline{AB}$, of the rocker arm. This is done by means of a screw device which is not shown.

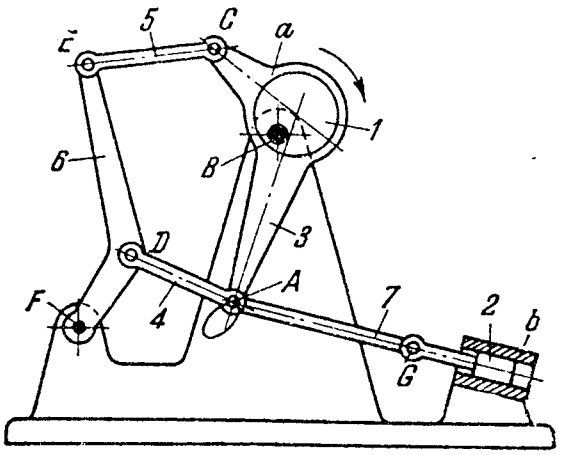
| 1528 | ECCENTRIC-TYPE SLIDER-CRANK MECHANISM WITH BAR STROKE ADJUSTMENT | SC 6L |
|---|---|---|




Connecting rod *4* has collar *b* encircling round eccentric *1* which rotates about fixed axis *A*. Pin *C* of connecting rod *4* slides along slotted link *2* which is rigidly mounted on the upright. When eccentric *1* rotates about axis *A*, bar *3* reciprocates in a fixed guide. The bar stroke is varied by turning slotted link *2* about point *F* and clamping it rigidly in the required position.

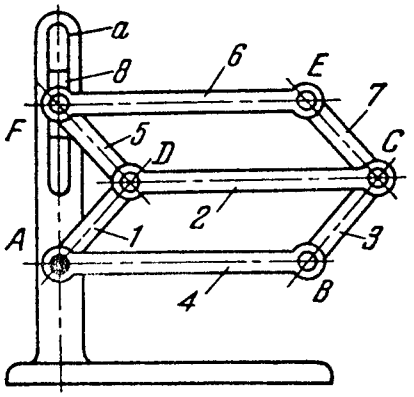
## 4. GENERAL-PURPOSE MULTIPLE-LINK MECHANISMS (1529 through 1534)

| 1529 | SLIDER-CRANK MECHANISM WITH A ROUND ECCENTRIC | SC ML |
|---|---|---|



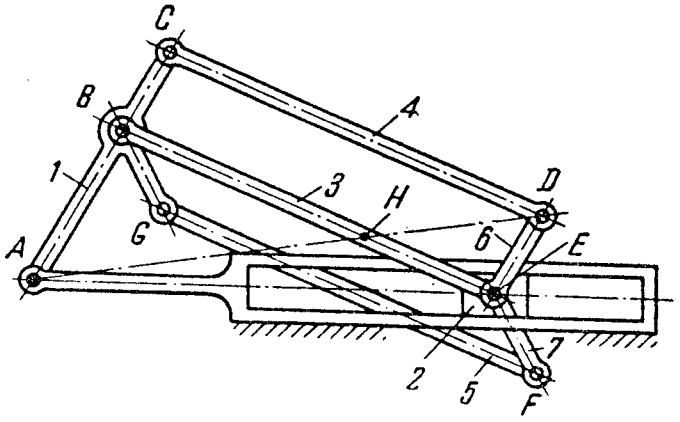

Round eccentric *1* rotates about fixed axis *B*. Link *3* has collar *a* encircling eccentric *1*, and is connected by turning pairs *A* and *C* to links *4* and *5*. Links *4* and *5* are connected by turning pairs *D* and *E* to link *6* which turns about fixed axis *F*. Connecting rod *7* is connected by turning pairs *A* and *G* to link *3* and to slider *2* which moves in fixed guides *b*. When eccentric *1* rotates about axis *B*, slider *2* reciprocates.

| 1530 | SLIDER-CRANK TRANSLATOR MECHANISM | SC ML |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AD} = \overline{BC}$, $\overline{DF} = \overline{CE}$ and $\overline{AB} = \overline{DC} = \overline{FE}$. Links *5* and *6* are connected by turning pairs *F* to slide which moves along straight guides *a*. The mechanism has two degrees of freedom. For any fixed position of link *4*, link *6* can only be moved so that it remains parallel to link *4*.

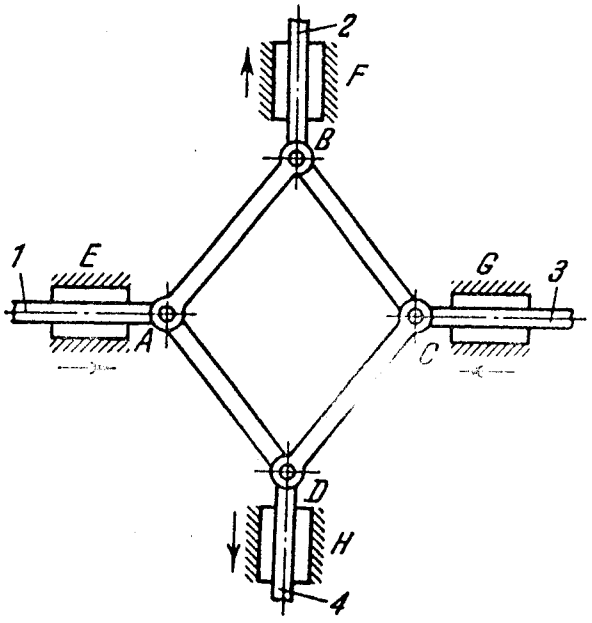
| 1531 | SLIDER-CRANK MECHANISM WITH ATTACHED PARALLELOGRAMS | SC ML |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{BC} = \overline{ED}$, $\overline{BG} = \overline{EF}$ and $\overline{CD} = \overline{BE} = \overline{GF}$. Attached to slider-crank linkage $ABE$ are links *4*, *5*, *6* and *7*. Figures $BEFG$ and $BCDE$ are parallelograms. The motion of links *4* and *5* is similar to that of link *3*. Thus, for example, point $D$ describes a connecting-rod curve similar to that described by point $H$ of link *3*, the similarity factor being

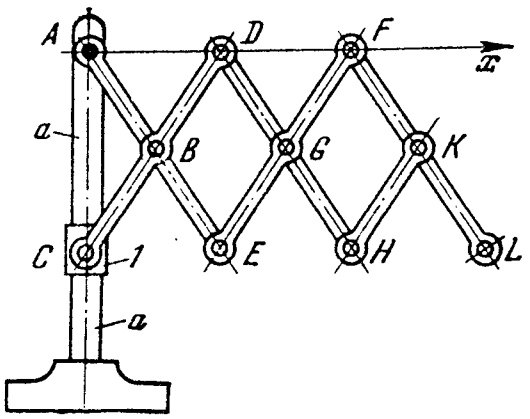
$$k = \frac{\overline{AC}}{\overline{AB}}.$$

| 1532 | RHOMBUS LINKAGE MECHANISM FOR TRANSLATIONAL MOTIONS | SC ML |
|---|---|---|



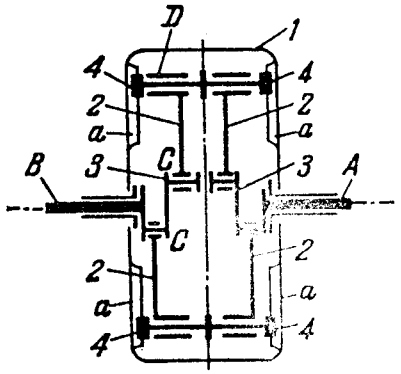

The lengths of the links comply with the condition: $\overline{AB} = \overline{BC} = \overline{CD} = \overline{DA}$. Rectilinear displacement of link *1* is converted into rectilinear displacement of links *2*, *3* and *4*. If the axes of sliding pairs $E$, $F$, $G$ and $H$ are arranged as shown, the velocities of points $A$ and $C$, and $B$ and $D$ are equal and of opposite signs.

| 1533 | SLIDER-CRANK MECHANISM WITH TWO RHOMBUS LINKAGES (LAZY TONGS) | SC ML |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AB} = \overline{BC} = \overline{BD} = \overline{BE} = \overline{EG} = \overline{DG} = \overline{GF} = \overline{GH} = \overline{FK} = \overline{HK} = \overline{KL}$. Slider *1* moves along fixed guides *a-a*. Points *D* and *F* travel along straight line *Ax* which is perpendicular to the axis of guides *a-a*. The velocity of point *F* is twice that of point *D* and their motions coincide in direction.

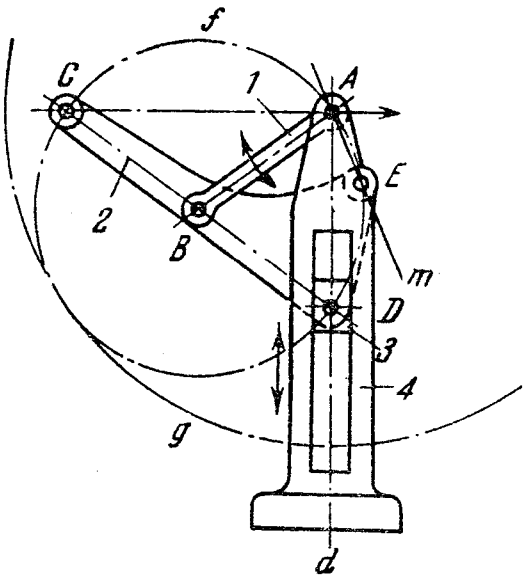
| 1534 | SLIDER-CRANK DIFFERENTIAL MECHANISM | SC ML |
|---|---|---|




The mechanism consists of housing *1* with guides *a* along which sliders *4* move. Semiaxles *A* and *B* have cranks *3*. Connecting rods *2* are connected by turning pairs *D* and *C* to sliders *4* and cranks *3*, Motion is transmitted from housing *1* through sliders *4*, connecting rods *2* and cranks *3* to semiaxles *A* and *B* which are connected to driving links of the mechanism. When the driving links at the two sides of the housing run at the same speed and in the same direction, there is relative motion in the slider-crank mechanisms. When the driving links run at different speeds, there is relative rotation between the two cranks *3*, and sliders *4* begin to reciprocate along the guides of housing *1*.

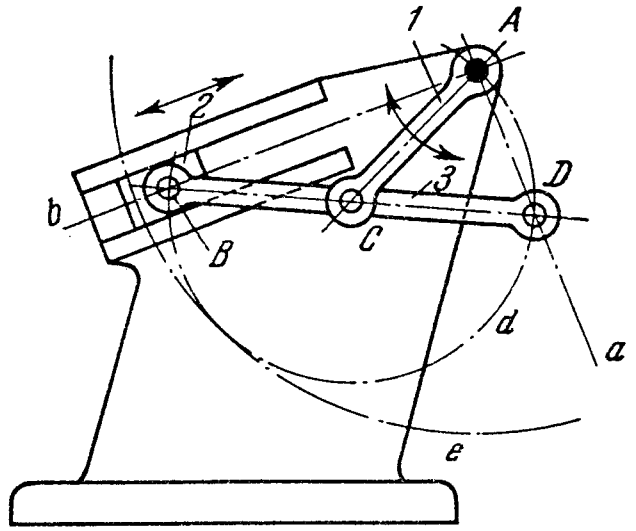
# 5. GUIDING MECHANISMS AND INVERSORS
## (1535 through 1559)

| 1535 | SLIDER-CRANK STRAIGHT-LINE MECHANISM | SC GI |
|---|---|---|



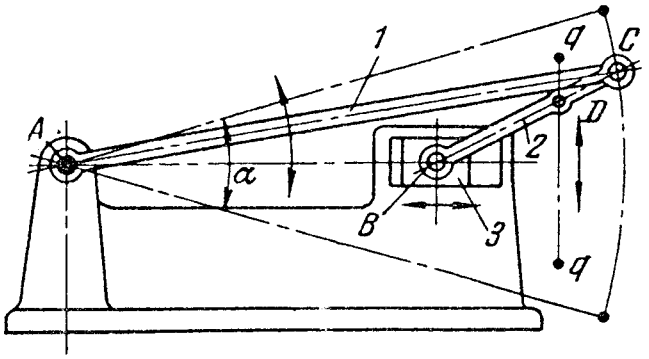

The lengths of the links comply with the condition: $\overline{AB} = \overline{BC} = \overline{BD}$. When link *3* moves along the fixed guides its point *D* travels along straight line *Ad*. Point *C* of link *2* travels along straight line *AC*. Any other point of link *2* lying on circle *f* of radius $\overline{BA}$, for example point *E*, also, like point *C*, moves along a straight line passing through point *A* (line *Am* for point *E*). The motion of link *2* can also be produced by the rolling of circle *f*, rigidly secured to link *2*, without slipping around fixed circle *g*, the radii of the circles being in the proportion $\overline{AB} : \overline{DC}$.

| 1536 | SLIDER-CRANK STRAIGHT-LINE MECHANISM | SC, GI |
|---|---|---|



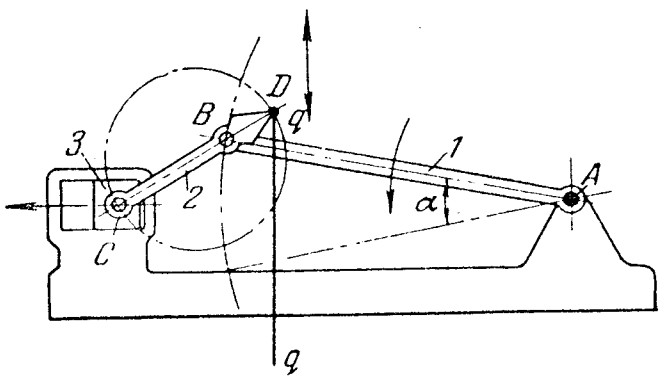

The lengths of the links comply with the condition: $\overline{AC} = \overline{BC} = \overline{CD}$. When link *2* moves along the fixed guides its point *B* travels along straight line *Ab*. Point *D* of link *3* travels along straight line *Aa*. Lines *Ab* and *Aa* are perpendicular to each other. The motion of link *3* can also be produced by the rolling of circle *d*, rigidly secured to link *3*, without slipping around fixed circle *e*, the radii of the circles being in the proportion $\overline{AC} : \overline{BD}$. If slider *2* is the driving link, link *1* oscillates about fixed axis *A*.

| 1537 | SLIDER-CRANK APPROXIMATE STRAIGHT-LINE MECHANISM | SC GI |
|---|---|---|



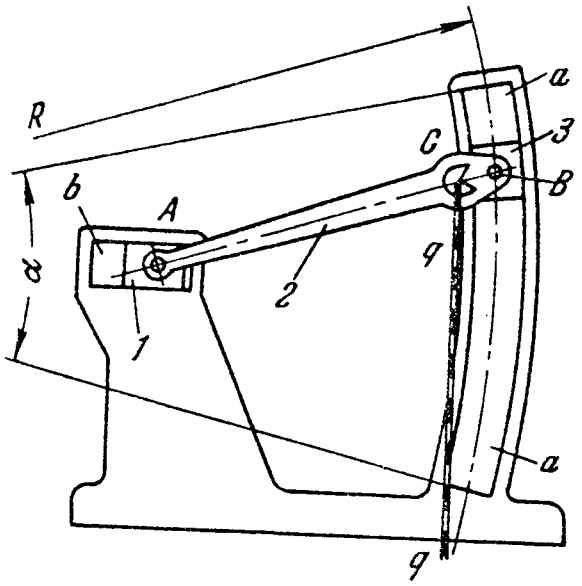

The lengths of the links of slider-crank linkage $ABC$ comply with the conditions: $\overline{BC} = 0.36\overline{AC}$ and $\overline{CD} = 0.125\overline{AC}$. When link *1* turns about fixed axis $A$, point $D$ of connecting rod *2* describes path $q$-$q$ which approximates a straight line over the portion corresponding to the turning of link *1* through an angle $\alpha \cong 25°$.

| 1538 | SLIDER-CRANK APPROXIMATE STRAIGHT-LINE MECHANISM | SC GI |
|---|---|---|



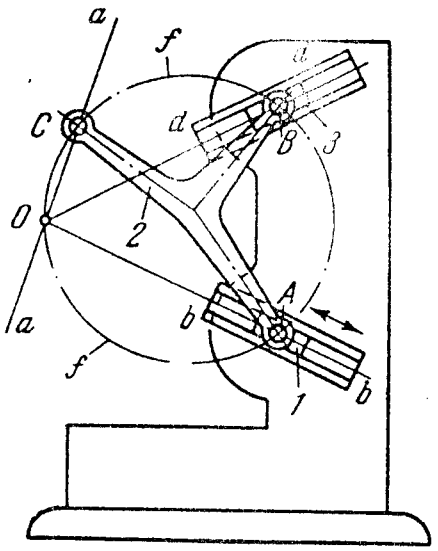

The lengths of the links of slider-crank linkage $ABC$ comply with the conditions: $\overline{AB} = 3.12\overline{BC}$ and $\overline{CD} = 1.35\overline{BC}$. When link *1* turns about fixed axis $A$, point $D$ of connecting rod *2* describes path $q$-$q$ which approximates a straight line over the portion corresponding to the turning of link *1* through an angle $\alpha \cong 25°$.

| 1539 | SLIDER-CRANK APPROXIMATE STRAIGHT-LINE MECHANISM | SC GI |
|---|---|---|



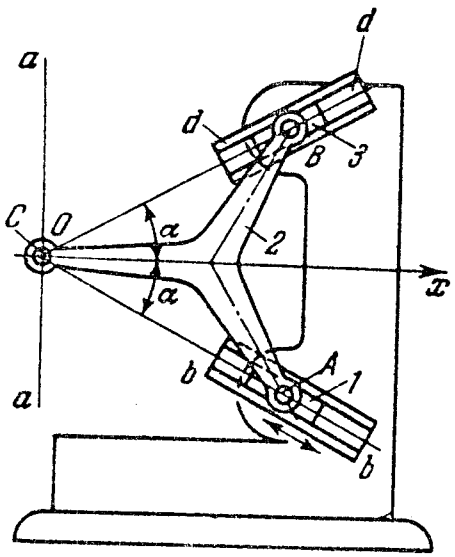

The lengths of the links of the slider-crank linkage comply with the conditions: $\overline{AC} = 0.83\overline{AB}$ and $R = 2.92\overline{AB}$, where $R$ is the radius of the fixed circular guides $a$-$a$ along which circular slider *3* travels. Radius $R$ is drawn from a centre lying on the axis of fixed guide $b$ along which slider *1* travels. When slider *1* moves along guide $b$, point $C$ of link *2* describes path $q$-$q$ which approximates a straight line over the portion corresponding to the travel of slider *3* through an angle $\alpha \cong 36°$.

| 1540 | REULEAUX FOUR-BAR SLIDER-CRANK STRAIGHT-LINE MECHANISM | SC GI |
|---|---|---|



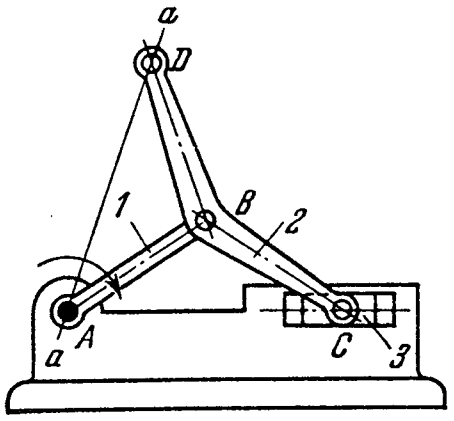

Link 2 is connected by turning pairs *A* and *B* to sliders *1* and *3* which move along fixed guides *b-b* and *d-d*. Point *C* of link *2* lies on a circle passing through point *O* of intersection of the axes of guides *b-b* and *d-d*, and through points *A* and *B*. When slider *1* moves along guides *b-b* point *C* describes straight line *a-a* passing through point *O*.

| 1541 | REULEAUX FOUR-BAR SLIDER-CRANK STRAIGHT-LINE MECHANISM | SC GI |
|---|---|---|



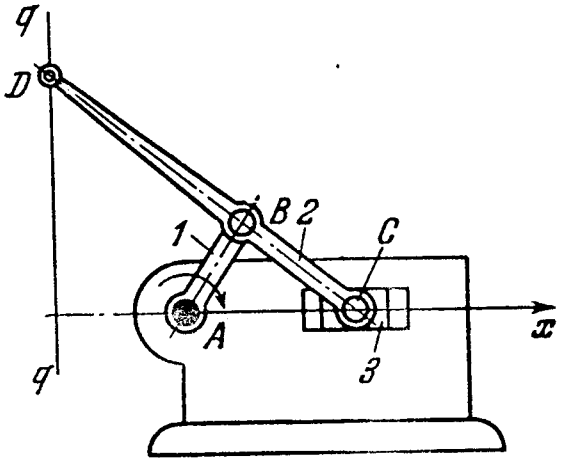

Link *2* is connected by turning pairs *A* and *B* to sliders *1* and *3* which move along fixed guides *b-b* and *d-d*. When slider *1* moves along guides *b-b*, point *C* of link *2*, at the point of intersection of the axes of guides *b-b* and *d-d*, describes straight line *a-a*. Line *a-a* is perpendicular to axis *Ox* which makes equal angles with the axes of guides *b-b* and *d-d*.

| 1542 | SCOTT-RUSSELL FOUR-BAR SLIDER-CRANK STRAIGHT-LINE MECHANISM | SC GI |
|---|---|---|



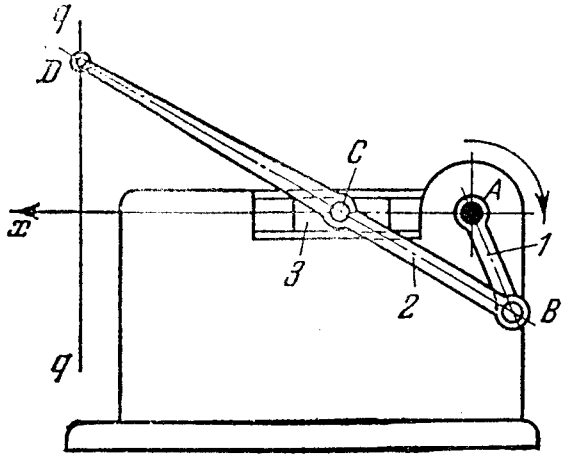

The lengths of the links of slider-crank linkage $ABC$ comply with the condition: $\overline{AB} = \overline{BC} = \overline{BD}$. When link *1* turns about fixed axis $A$, point $D$ of link *2* describes straight line *a-a*.

| 1543 | FOUR-BAR SLIDER-CRANK APPROXIMATE STRAIGHT-LINE MECHANISM | SC GI |
|---|---|---|



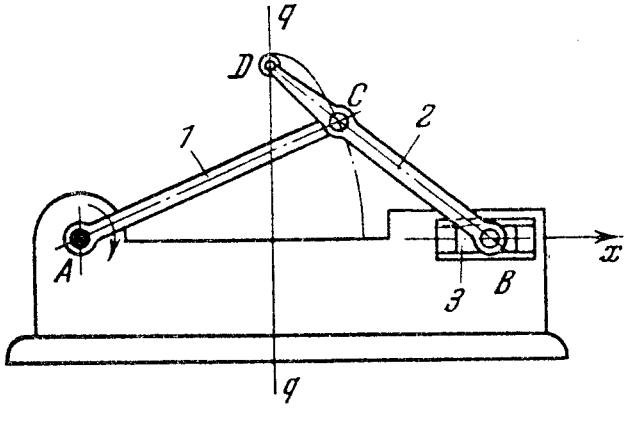

The lengths of the links of slider-crank linkage $ABC$ comply with the conditions: $\overline{BC} = 1.37\overline{AB}$ and $\overline{BD} = 2.27\overline{AB}$. When crank *1* turns about fixed axis $A$, point $D$ of connecting rod *2* describes a path of which a certain portion approximates straight line *q-q*, perpendicular to axis $Ax$ of motion of slider *3*.

| 1544 | FOUR-BAR SLIDER-CRANK APPROXIMATE STRAIGHT-LINE MECHANISM | SC GI |
|---|---|---|



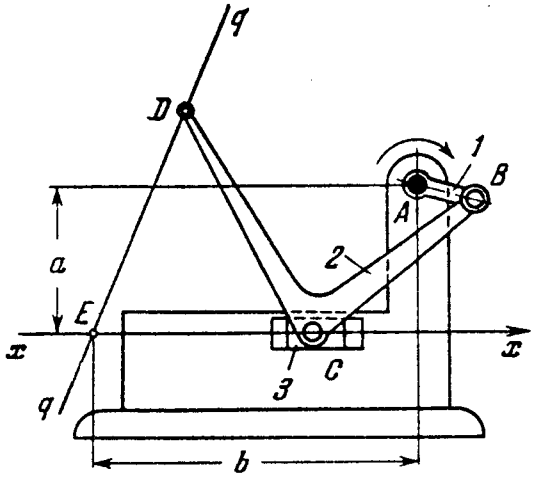

The lengths of the links of slider-crank linkage $ABC$ comply with the conditions: $\overline{BC} = 1.86\overline{AB}$ and $\overline{CD} = 2.76\overline{AB}$. When crank *1* turns about fixed axis $A$, point $D$ of connecting rod *2* describes a path of which a certain portion approximates straight line $q$-$q$, perpendicular to axis $Ax$ of motion of slider *3*.

| 1545 | FOUR-BAR SLIDER-CRANK APPROXIMATE STRAIGHT-LINE MECHANISM | SC GI |
|---|---|---|

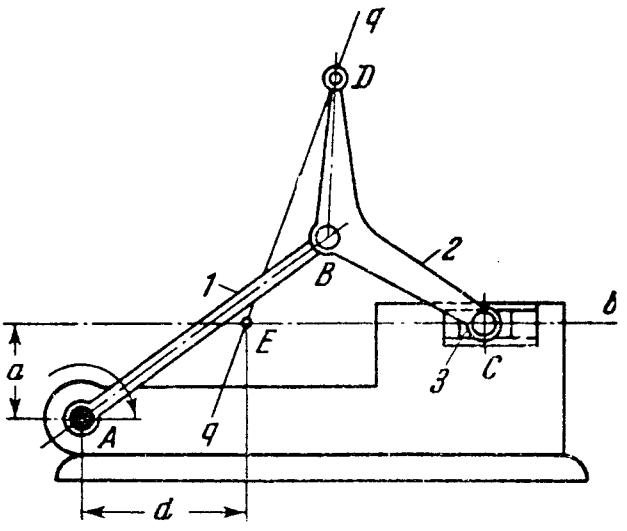



The lengths of the links of slider-crank linkage $ABC$ comply with the conditions: $\overline{BC} = 0.67\overline{AC}$ and $\overline{CD} = 0.3\overline{AC}$. When link *1* turns about fixed axis $A$, point $D$ of connecting rod *2* describes a path of which a certain portion approximates straight line $q$-$q$, perpendicular to axis $Ax$ of motion of slider *3*.

| 1546 | FOUR-BAR SLIDER-CRANK APPROXIMATE STRAIGHT-LINE MECHANISM | SC GI |
|---|---|---|



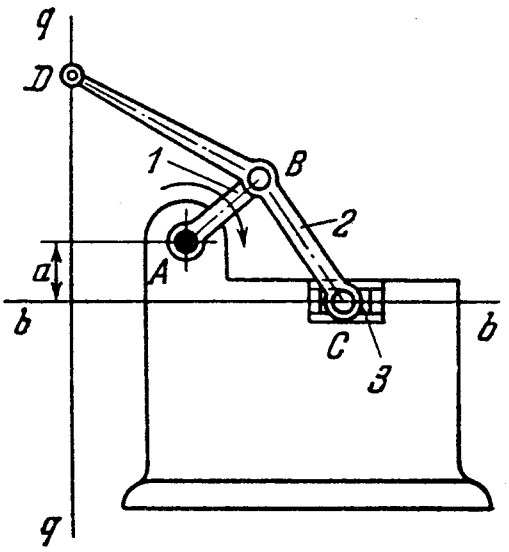

The lengths of the links of slider-crank linkage $ABC$ comply with the conditions: $\overline{BC} = 3.5\overline{AB}$, $\overline{CD} = 4.2\overline{AB}$, $\overline{BD} = 5.1\overline{AB}$, $b = 5.43\overline{AB}$ and $a = 2.49\overline{AB}$. When crank *1* turns about fixed axis $A$, point $D$ of connecting rod *2* describes a path of which a certain portion approximates straight line $q$-$q$, passing through point $E$. Point $E$ lies on axis $x$-$x$ of motion of slider *3*.




The lengths of the links of slider-crank linkage $ABC$ comply with the conditions: $\overline{BC} = 0.58\overline{AB}$, $\overline{BD} = 0.51\overline{AB}$, $\overline{DC} = 0.93\overline{AB}$, $a = 0.32\overline{AB}$ and $d = 0.57\overline{AB}$. When crank *1* turns about fixed axis $A$, point $D$ of connecting rod *2* describes a path of which a certain portion approximates straight line $q$-$q$, passing through point $E$. Point $E$ lies on axis $b$-$b$ of motion of slider *3*.

## 1548 DE JONGE FOUR-BAR SLIDER-CRANK APPROXIMATE STRAIGHT-LINE MECHANISM

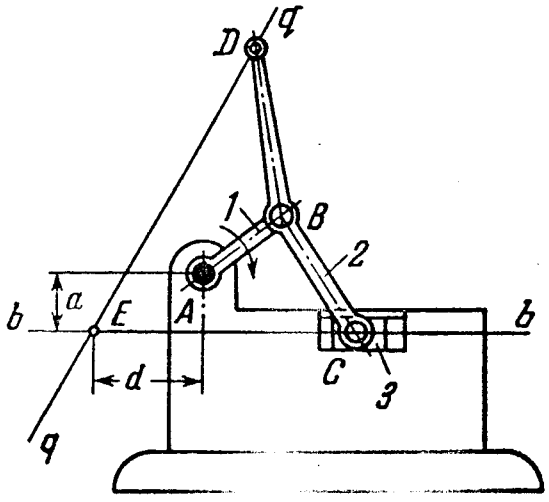
SC GI




The lengths of the links of slider-crank linkage $ABC$ comply with the conditions: $\overline{BC} = 1.52\overline{AB}$, $\overline{DC} = 3.7\overline{AB}$, $\overline{DB} = 2.26\overline{AB}$ and $a = 0.61\overline{AB}$. When crank *1* turns about fixed axis $A$, point $D$ of connecting rod *2* describes a path of which a certain portion approximates straight line $q$-$q$, perpendicular to axis $b$-$b$ of motion of slider *3*.

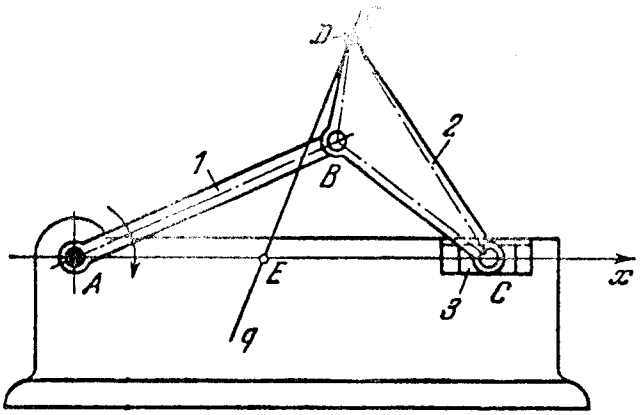
## 1549 DE JONGE FOUR-BAR SLIDER-CRANK APPROXIMATE STRAIGHT-LINE MECHANISM

SC GI



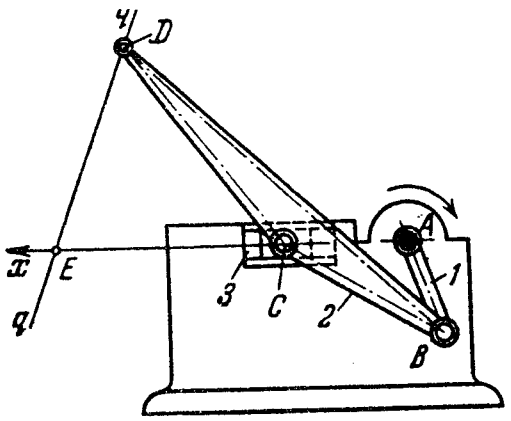

The lengths of the links of slider-crank linkage $ABC$ comply with the conditions: $\overline{BC} = 1.42\overline{AB}$, $\overline{BD} = 1.67\overline{AB}$, $\overline{DC} = 3\overline{AB}$. $a = 0.58AB$ and $d = 1.08\overline{AB}$ When crank *1* turns about fixed axis $A$, point $D$ of connecting rod *2* describes a path of which a certain portion approximates straight line $q$-$q$, passing through point $E$. Point $E$ lies on axis $b$-$b$ of motion of slider *3*.

| 1550 | DE JONGE FOUR-BAR SLIDER-CRANK APPROXIMATE STRAIGHT-LINE MECHANISM | SC GI |
|---|---|---|



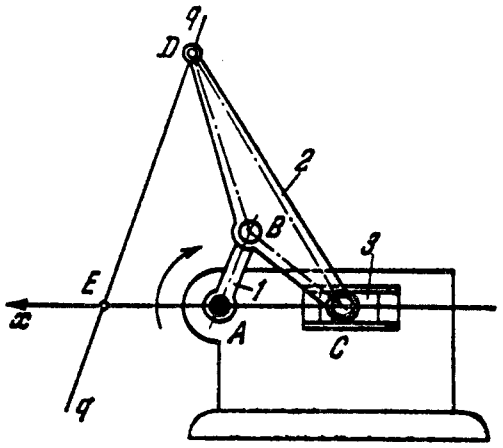

The lengths of the links of slider-crank linkage $ABC$ comply with the conditions: $\overline{BC} = 0.66\overline{AB}$, $\overline{BD} = 0.37\overline{AB}$, $\overline{DC} = 0.9\overline{AB}$ and $\overline{AE} = 0.66\overline{AB}$. When link *1* turns about fixed axis $A$, point $D$ of connecting rod *2* describes a path of which a certain portion approximates straight line $q$-$q$, passing through point $E$. Point $E$ lies on axis $Ax$ of motion of slider *3*.

| 1551 | DE JONGE FOUR-BAR SLIDER-CRANK APPROXIMATE STRAIGHT-LINE MECHANISM | SC GI |
|---|---|---|



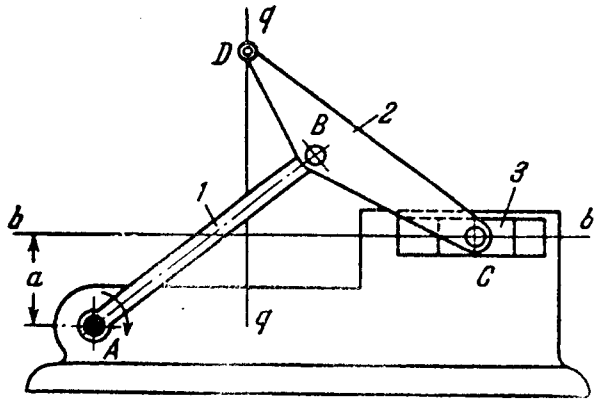

The lengths of the links of slider-crank linkage $ABC$ comply with the conditions: $\overline{BC} = 1.33\overline{AB}$, $\overline{BD} = 4.25\overline{AB}$, $\overline{CD} = 2.64\overline{AB}$ and $\overline{AE} = 3.72\overline{AB}$. When crank *1* turns about fixed axis $A$, point $D$ of connecting rod *2* describes a path of which a certain portion approximates straight line $q$-$q$, passing through point $E$. Point $E$ lies on axis $Ax$ of motion of slider *3*.

| 1552 | DE JONGE FOUR-BAR SLIDER-CRANK APPROXIMATE STRAIGHT-LINE MECHANISM | SC GI |
|---|---|---|



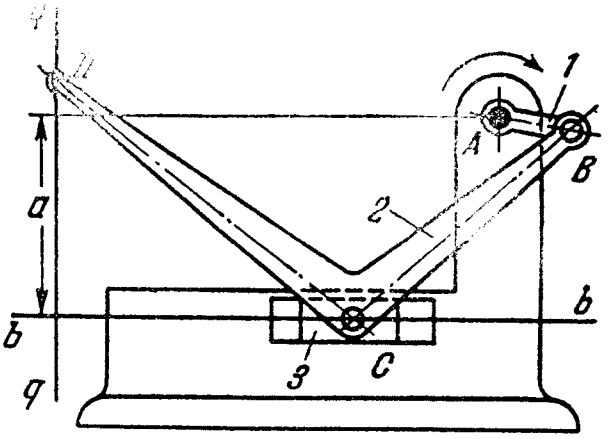

The lengths of the links of slider-crank linkage $ABC$ comply with the conditions: $\overline{BC} = 1.48\overline{AB}$, $\overline{BD} = 2.28\overline{AB}$, $\overline{CD} = 3.62\overline{AB}$ and $\overline{AE} = 1.38\overline{AB}$. When crank *1* turns about fixed axis $A$, point $D$ of connecting rod *2* describes a path of which a certain portion approximates straight line $q$-$q$, passing through point $E$. Point $E$ lies on axis $Ax$ of motion of slider *3*.

| 1553 | DE JONGE FOUR-BAR SLIDER-CRANK APPROXIMATE STRAIGHT-LINE MECHANISM | SC GI |
|---|---|---|



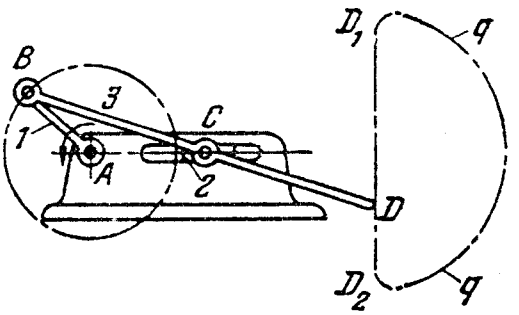

The lengths of the links of slider-crank linkage $ABC$ comply with the conditions: $\overline{BC} = 0.65\overline{AB}$, $\overline{BD} = 1.45\overline{AB}$, $\overline{DC} = 1.1\overline{AB}$ and $a = 0.32\overline{AB}$. When link *1* turns about fixed axis $A$, point $D$ of connecting rod *2* describes a path of which a certain portion approximates straight line $q$-$q$, perpendicular to axis $b$-$b$ of motion of slider *3*.

| 1554 | DE JONGE FOUR-BAR SLIDER-CRANK APPROXIMATE STRAIGHT-LINE MECHANISM | SC GI |
|---|---|---|



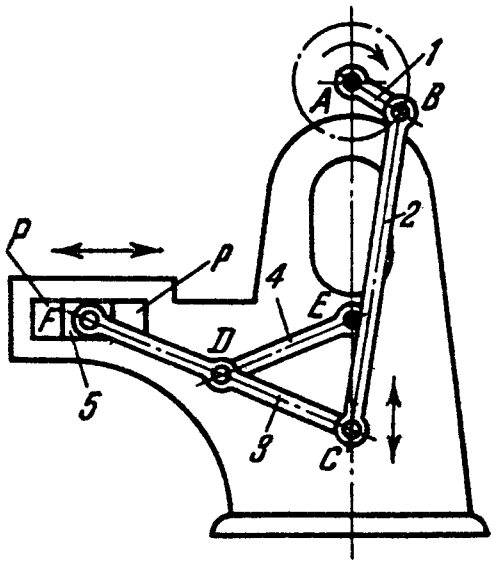

The lengths of the links of slider-crank linkage $ABC$ comply with the conditions: $\overline{BC} = 4\overline{AB}$, $\overline{BD} = 7.1\overline{AB}$, $\overline{CD} = 5.25\overline{AB}$ and $a = 3.25\overline{AB}$. When crank *1* turns about fixed axis $A$, point $D$ of connecting rod *2* describes a path of which a certain portion approximates straight line $q$-$q$, perpendicular to axis $b$-$b$ of motion of slider *3*.

| 1555 | SLIDER-CRANK APPROXIMATE STRAIGHT-LINE MECHANISM | SC GI |
|---|---|---|

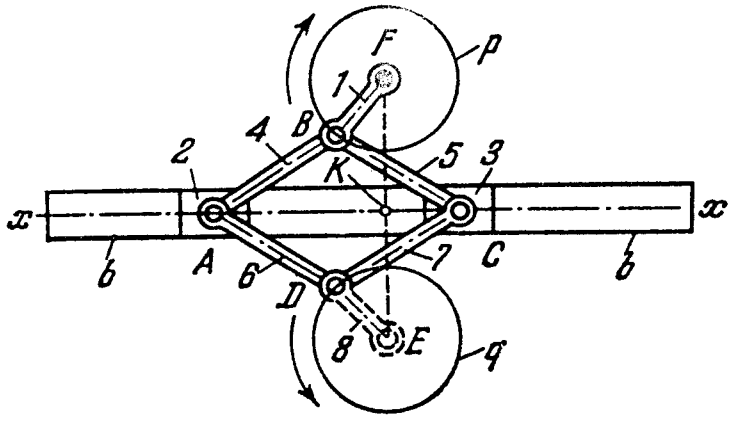



The lengths of the links comply with the conditions: $\overline{BC} = 2.3\overline{AB}$ and $\overline{CD} = 2.2\overline{AB}$. When crank *1* rotates about fixed axis $A$, point $D$ of connecting rod *3* of the slider-crank mechanism $ABC$ describes connecting-rod curve $q$-$q$ of which a certain portion, between the positions $D_1$ and $D_2$ (of point $D$) approximates a straight line.

| 1556 | SLIDER-CRANK EXACT STRAIGHT-LINE MECHANISM | SC GI |
|---|---|---|




The lengths of the links comply with the condition: $\overline{ED} = \overline{DF} = \overline{DC}$. Link *1* rotates about fixed axis *A* and is connected by turning pair *B* to link *2* which, in turn, is connected by turning pair *C* to link *3*. Link *3* is connected by turning pairs *D* and *F* to link *4* and slider *5*. Link *4* turns about fixed axis *E*, and slider *5* moves in fixed guides *p-p*. When link *1* rotates about axis *A*, point *C* describes a straight line.

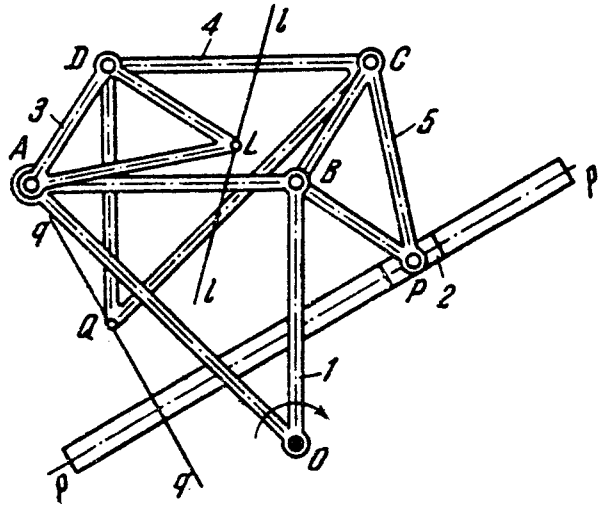



The lengths of the links comply with the conditions: $\overline{AB} = \overline{BC} = \overline{CD} = \overline{DA}$ and $\overline{FK} = \overline{KE}$. Figure $ABCD$ is a rhombus linkage. Link *1* rotates about fixed axis $F$ and is connected by turning pairs $B$ to links *4* and *5*. Links *4* and *6*, and *5* and *7* are connected by turning pairs $A$ and $C$ to sliders *2* and *3* which move along guides *b-b*. When link *1* rotates about axis $F$, point $B$ describes circle $p$ of radius $\overline{FB}$, and point $D$ describes circle $q$ of radius $\overline{ED} = \overline{FB}$. Point $E$ lies on straight line $FKE$, perpendicular to axis *x-x* of guides *b-b*. Therefore, if we add link *8* shown by dash lines, the mechanism has a constant transmission ratio between links *1* and *8* equal to

$$i_{18} = \frac{\omega_1}{\omega_8} = -1.$$

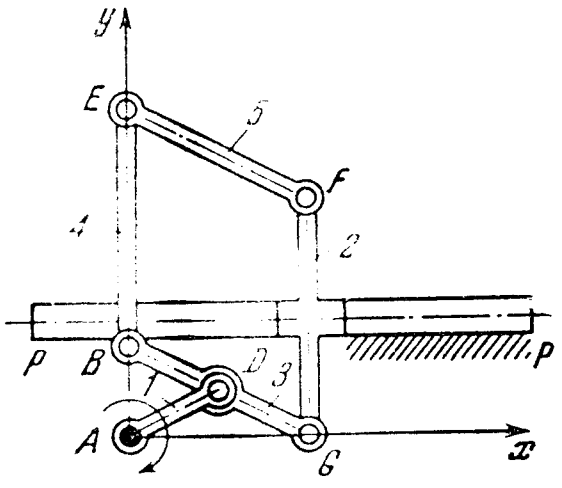
Links *6*, *7* and *8* are the mirror images of links *4*, *5* and *1* with respect to axis *x-x*. Links *1* and *3* rotate in opposite directions.

| 1558 | SLIDER-CRANK EXACT STRAIGHT-LINE MECHANISM WITH A PARALLELOGRAM | SC GI |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AD} = \overline{BC} = \overline{DL} = \overline{BP}$, $\overline{DC} = \overline{AB} = \overline{DQ} = \overline{BO}$ and $\angle ADL = \angle CBP = \angle CDQ = \angle ABO = 90°$. Figure $ABCD$ is a parallelogram linkage. Link *1* turns about fixed axis $O$. Link *5* is connected by turning pair $P$ to slider *2* which moves along fixed guides $p$-$p$. When link *1* turns about axis $O$, point $L$ of link *3* and point $Q$ of link *4* describe straight lines $l$-$l$ and $q$-$q$. Line $q$-$q$ is perpendicular to axis $p$-$p$ of the guides and line $l$-$l$ makes an angle of 45° with axis $p$-$p$. Points $O$, $Q$, $L$ and $P$ always form a square.

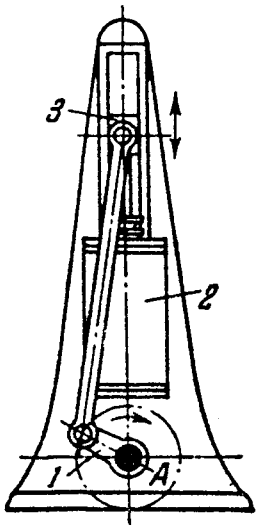
| 1559 | ARTOBOLEVSKY SLIDER-CRANK STRAIGHT-LINE MECHANISM HAVING A LINK WITH RECTILINEAR TRANSLATION | SC CA |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AD} = \overline{DG} = \overline{DB}$, $\overline{BE} = \overline{GF}$ and $\overline{EF} = \overline{BG}$. Figure $BEFG$ is a parallelogram linkage. Link *1* rotates about fixed axis $A$ and is connected by turning pair $D$ to link *3* which, in turn, is connected by turning pairs $B$ and $G$ to link *4* and to slider *2*. Slider *2* moves along fixed guides $p$-$p$ whose axis is parallel to axis $Ax$. Link *5* is connected by turning pairs $F$ and $E$ to slider *2* and to link *4*. When link *1* rotates about axis $A$, link *4* has rectilinear translation along axis $Ay$.

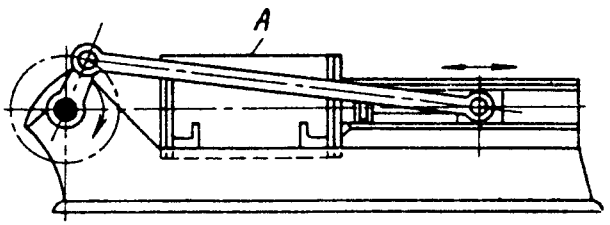
# 6. PISTON MACHINE MECHANISMS
## (1560 through 1591)

| 1560 | ALIGNED SLIDER-CRANK ENGINE MECHANISM | SC PM |
|---|---|---|




The axis of the cylinder passes through axis *A* of rotation of crank *1*. The times for the forward and return strokes of the piston are equal. Slider *3* is connected to two slider-crank mechanisms that are symmetrical with respect to the axis of cylinder *2* (only the front mechanism is shown). The cranks rotate in opposite directions.

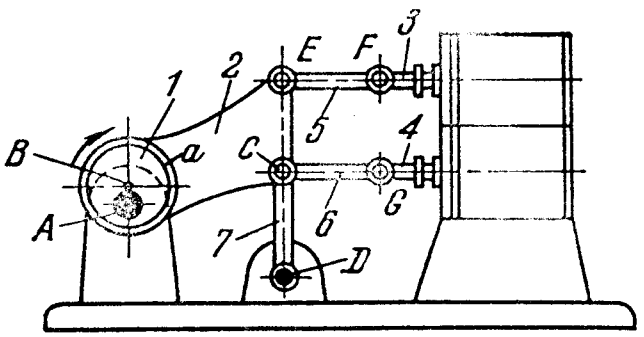
| 1561 | ALIGNED SLIDER-CRANK ENGINE MECHANISM | SC PM |
|---|---|---|




To reduce the overall size of the engine, the connecting rod is designed as two parallel rods between which the working cylinder *A* is arranged. Only the front connecting rod is shown.

## 1562 SLIDER-CRANK PISTON MACHINE MECHANISM

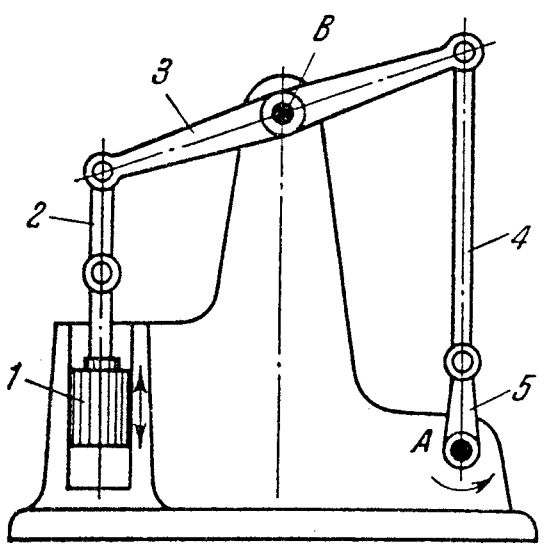
SC




Connecting rod *2* of four-bar linkage *ABCD* has collar *a* encircling round eccentric *1* which rotates about fixed axis *A*. Connecting rod *5* is connected by turning pairs *E* and *F* to connecting rod *2* and piston rod *3*. Connecting rod *6* is connected by turning pairs *C* and *G* to rocker arm *7*, connecting rod *2* and piston rod *4*. When eccentric *1* rotates about axis *A*, piston rods *3* and *4* reciprocate.

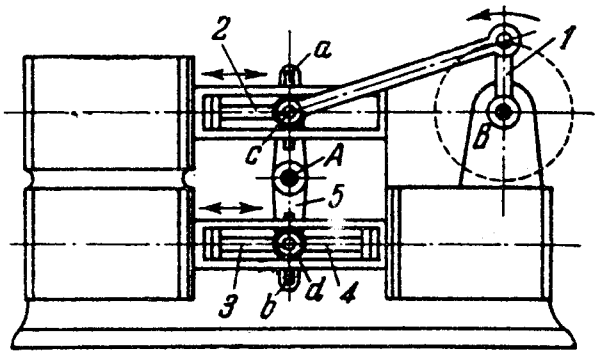
## 1563 SLIDER-CRANK BEAM-ENGINE MECHANISM

SC
PM



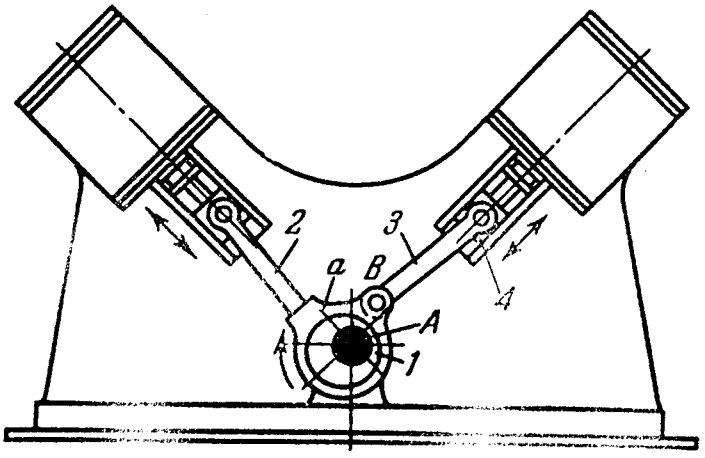

Crank *5* rotates about fixed axis *A* and, through connecting rod *4*, oscillates beam *3* about fixed axis *B*. Through connecting rod *2*, beam *3* transmits reciprocating motion to the rod of piston *1*. Beam *3* is balanced with respect to its axis *B* of rotation.

| 1564 | SLIDER-CRANK PISTON-MACHINE MECHANISM | SC PM |
|---|---|---|



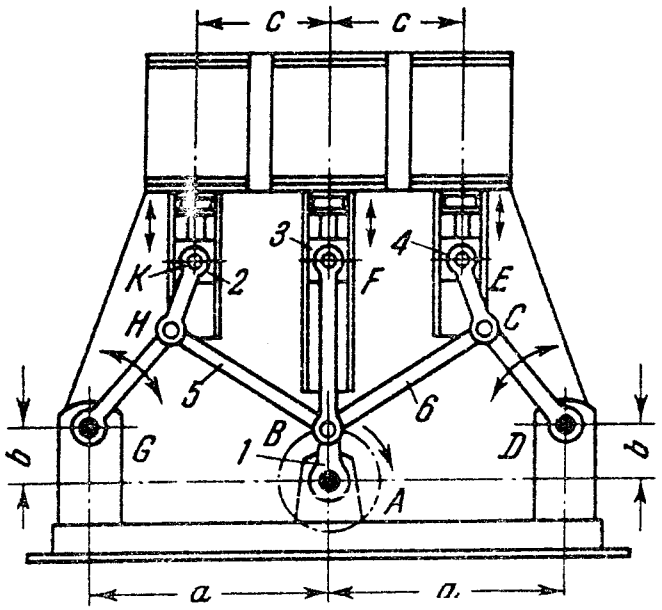

Link *5*, oscillating about fixed axis *A*, has slots *a* and *b* along which pins *c* and *d* slide. Pins *c* and *d* are rigidly secured to piston rods *2*, *3* and *4*. When crank *1* rotates about fixed axis *B*, piston rod *2* reciprocates. Slotted link *5* oscillates about axis *A* and thereby reciprocates piston rods *3* and *4*. If link *5* has equal arms, the strokes of piston rods *2*, *3* and *4* will be equal.

| 1565 | ECCENTRIC-TYPE SLIDER-CRANK ENGINE MECHANISM WITH ATTACHED CONNECTING ROD AND SLIDER | SC PM |
|---|---|---|



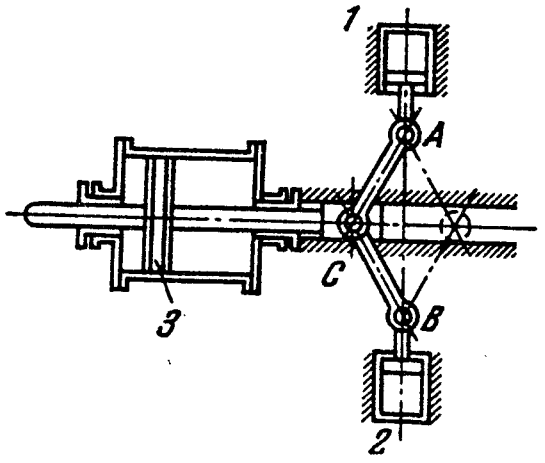

Crank *1* is designed as a round eccentric rotating about fixed axis *A*. Link *2* has collar *a* encircling eccentric *1*. Collar *a* has a lug connected by turning pair *B* to connecting rod *3* which, in turn, is connected by a turning pair to slider *4*. The axes of the cylinders pass through axis *A* of rotation of eccentric *1*.

| 1566 | SLIDER-CRANK MECHANISM OF A THREE-CYLINDER ENGINE | SC PM |
|---|---|---|



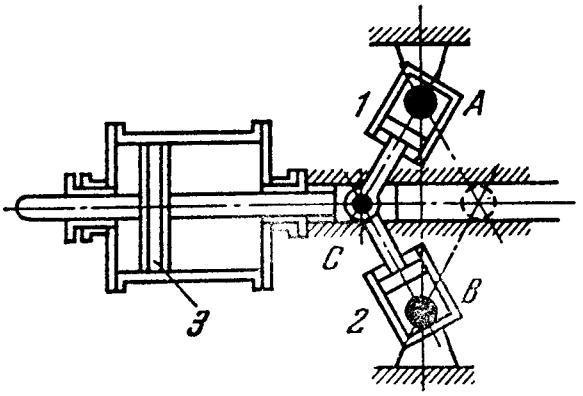

The lengths of the links comply with the conditions: $\overline{BC} = \overline{BH}$, $\overline{GH} = \overline{DC}$ and $\overline{HK} = \overline{CE}$. Added to the basic slider-crank linkage $ABF$ are connecting rods *5* and *6* of symmetrically arranged slider-crank linkages $GHK$ and $DCE$. When crank *1* rotates about fixed axis $A$, pistons *2*, *3* and *4* reciprocate. Pistons *2* and *4* have equal strokes and, in the general case, they are not equal to the stroke of piston *3*.

| 1567 | WORTHINGTON SLIDER MECHANISM FOR EQUALIZING CYLINDERS | SC PM |
|---|---|---|



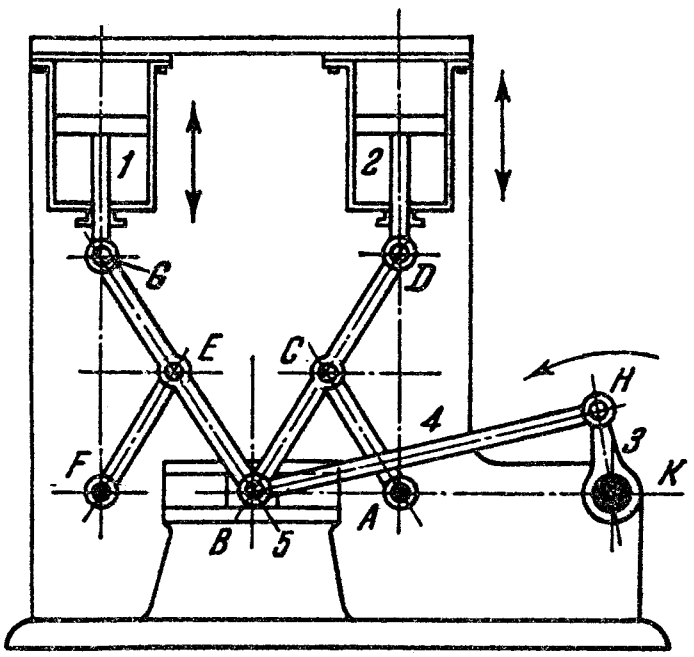

The lengths of the links comply with the condition: $\overline{BC} = \overline{AC}$. Cylinders *1* and *2* accumulate energy during the first half of the stroke of piston *3* and give it up during the second half.

| 1568 | WORTHINGTON LINK-GEAR MECHANISM FOR EQUALIZING CYLINDERS | SC PM |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AC} = \overline{BC}$. Cylinders 1 and 2 oscillate about fixed axes *A* and *B*, accumulating energy during the first half of the stroke of piston 3 and giving it up during the second half.

| 1569 | SLIDER-CRANK MECHANISM OF A TWO-CYLINDER ENGINE | SC PM |
|---|---|---|

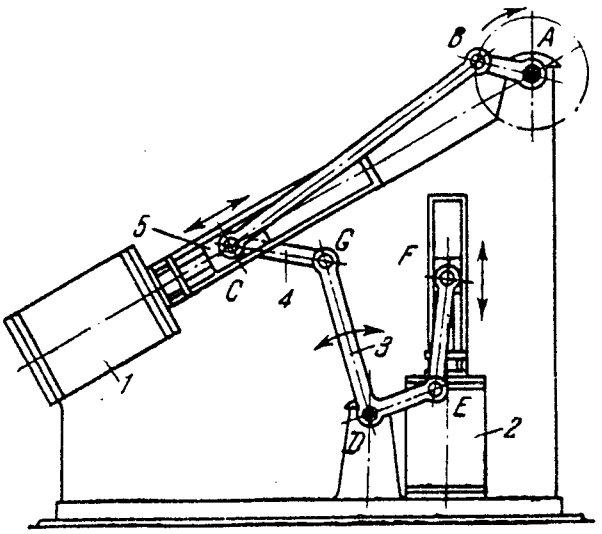



The lengths of the links comply with the condition: $\overline{AC} = \overline{BC} = \overline{CD} = \overline{BE} = \overline{FE} = \overline{EG}$. When crank *3* rotates about fixed axis *K*, points *D* and *G* travel in straight lines passing through points *A* and *F*. The axes of the cylinders coincide with straight lines *FG* and *AD*. The displacement $s_5$ of slider *5* is related to the displacement $s_1$ of piston *1* by the equation

$$s_5 = \sqrt{s_1 (2\overline{BG} - s_1)}.$$

## 1570 SLIDER-CRANK MECHANISM WITH TWO ARBITRARILY LOCATED CYLINDERS

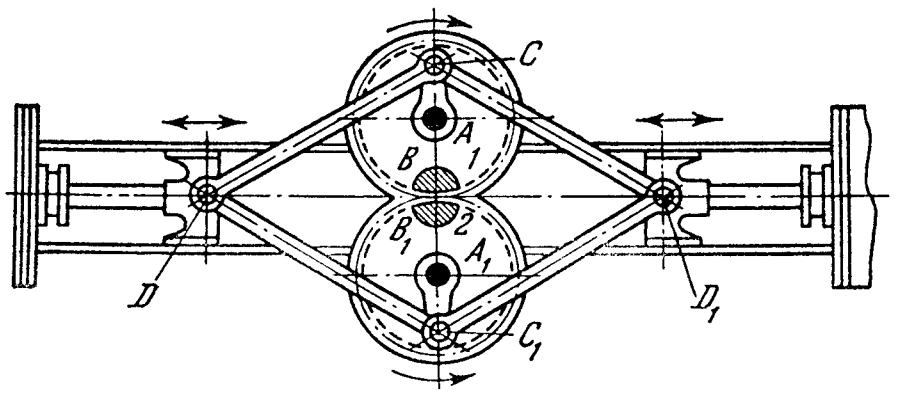
SC PM




Two arbitrarily located cylinders *1* and *2* are actuated by slider-crank linkages *ABC* and *DEF*. Crank *3* has the form of a bent link and is connected by turning pair *G* to connecting rod *4* which, in turn, is connected by turning pair *C* to slider *5*.

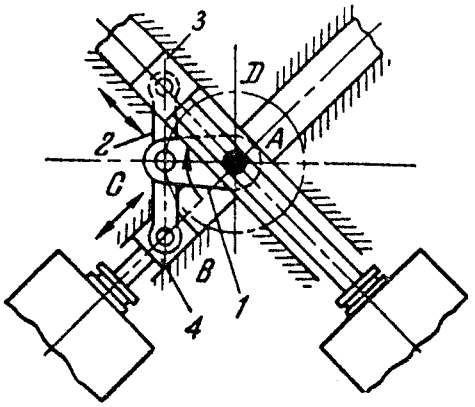
## 1571 SLIDER-CRANK MECHANISM WITH EQUALIZING COUNTERWEIGHTS

SC PM



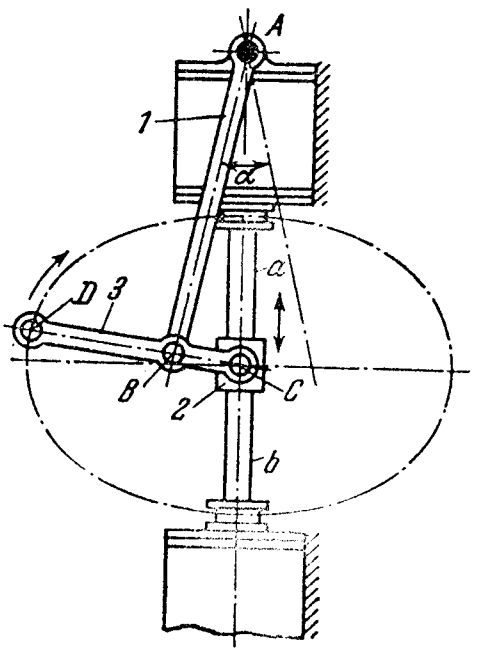

The lengths of the links comply with the conditions: $\overline{DC} = \overline{CD_1} = \overline{D_1C_1} = \overline{C_1D}$ and $\overline{AC} = \overline{A_1C_1}$. Cranks $AC$ and $A_1C_1$ are rigidly secured to the meshing gears, *1* and *2*, of equal size. Gears *1* and *2* carry two equal counterweights $B$ and $B_1$ which counterbalance inertia forces of the first order that are developed in the motion of the mechanism.

| 1572 | SLIDER-CRANK MECHANISM OF A TWO-CYLINDER ENGINE | SC PM |
|---|---|---|




The lengths of the links comply with the condition: $\overline{BC} = \overline{CD} = \overline{AC}$. The axes of the cylinders are perpendicular to each other. Crank *1* turns about fixed axis *A* and is connected by turning pair *C* to connecting rod *2* which, in turn, is connected by turning pairs to slides *3* and *4*. The stroke *s* of the pistons is four times the length $\overline{AC}$ of crank *1*. Sliders *3* and *4* move in parallel planes.

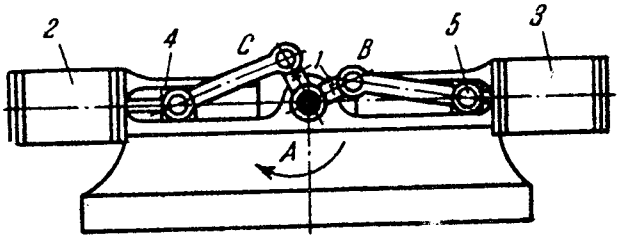
| 1573 | SLIDER-CRANK MECHANISM OF A HAND-OPERATED PUMP | SC PM |
|---|---|---|




Link *1* oscillates about fixed axis *A*, turning through the angle $\alpha = 2 \arctan \frac{\overline{BC}}{\overline{AB}}$. Piston rods *a* and *b* are rigidly secured to slider *2*. A handle is provided at point *D* of link *3*. For the dimensions shown point *D* describes a curve of oval shape.

## 1574 ALIGNED SLIDER-CRANK MECHANISM OF A TWO-CYLINDER ENGINE

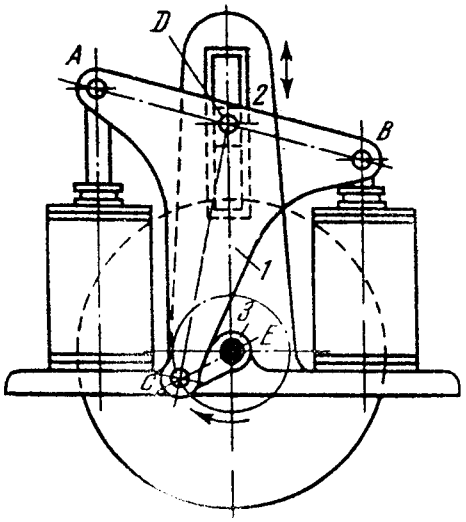
SC
PM




The axes of cylinders *2* and *3* pass through fixed axis *A* of rotation of crank *1*. Crank *1* has arms *AB* and *AC* which may be of different lengths. As a result, sliders *4* and *5* may be imparted different kinds of motion.

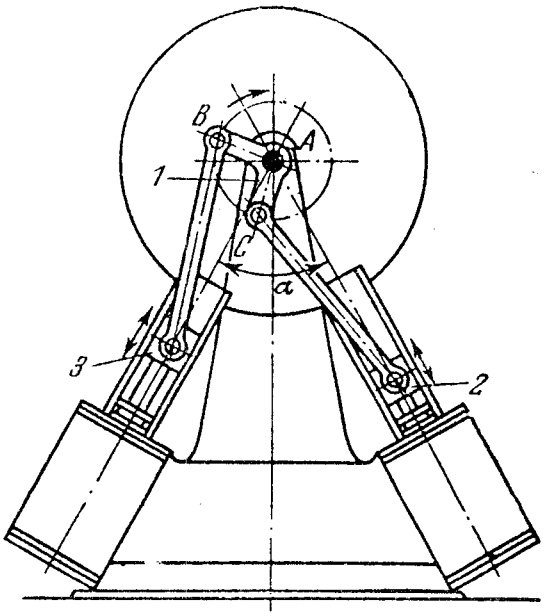
## 1575 SLIDER-CRANK MECHANISM OF A TWO-CYLINDER ENGINE

SC
PM



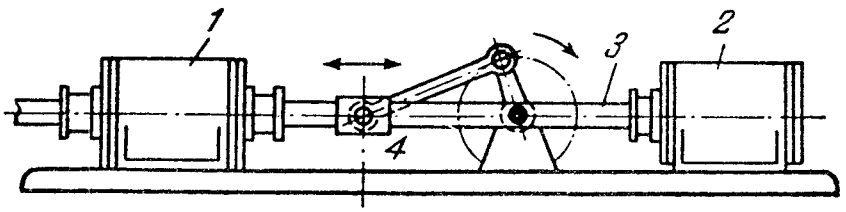

Connecting rod *1* is designed as triangular yoke *ABC* and is connected by turning pair *D*, at the middle of distance $\overline{AB}$, to slider *2*. Points *A* and *B* of connecting rod *1* describe portions of connecting-rod curves. At low values of ratio $\frac{\overline{EC}}{\overline{CD}}$ the portions of the connecting-rod curves approximate straight lines coinciding with the axes of the cylinders. For the mechanism to operate, clearances must be provided in the kinematic pairs.

| 1576 | SLIDER-CRANK MECHANISM OF A V-TYPE ENGINE | SC PM |
|---|---|---|




The axes of the cylinders pass through fixed axis *A* of rotation of crank *1* and make the angle α with each other. In the general case, arms *AB* and *AC* may be of different lengths. Angle *BAC* can be selected arbitrarily. As a result, sliders *2* and *3* may be imparted different kinds of motion.

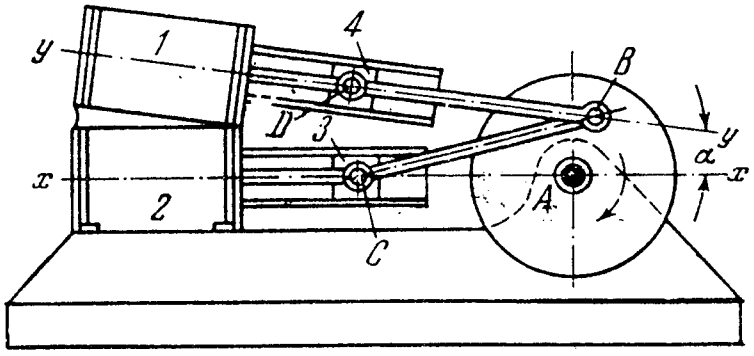
| 1577 | SLIDER-CRANK MECHANISM OF A TWO-CYLINDER ENGINE | SC PM |
|---|---|---|




The pistons of cylinders *1* and *2* have a common piston rod *3* to which slider *4* is rigidly secured.

## 1578 SLIDER-CRANK MECHANISM OF A TWO-CYLINDER ENGINE

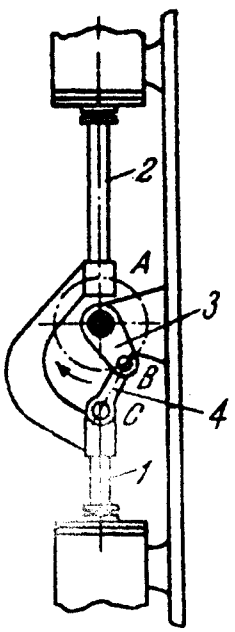
SC PM




Axis *y-y* of cylinder *1* makes a certain angle $\alpha$ with axis *x-x* of horizontal cylinder *2*. Thus, mechanism *ABC* is aligned and mechanism *ABD* is offset. The times of the forward and return strokes are equal for slider *3* and unequal for slider *4*.

## 1579 SLIDER-CRANK MECHANISM OF A TWO-CYLINDER ENGINE

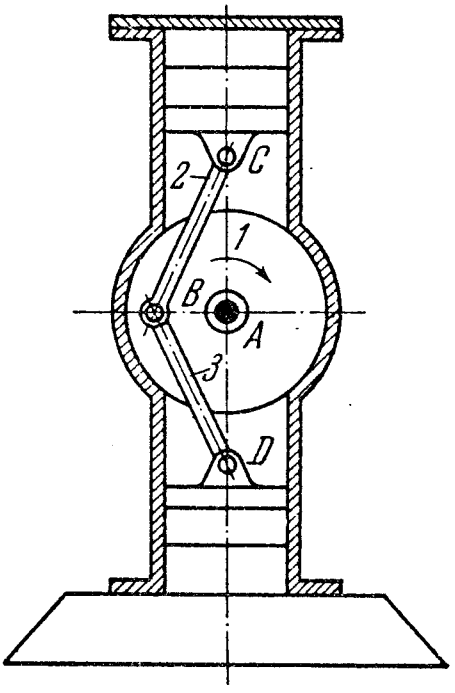
SC PM




Interlocked piston rods *1* and *2* are reciprocated by crank *3* through connecting rod *4*. The lengths of the links comply with the condition: $\overline{AB} = \overline{BC}$. Therefore the stroke of link *2* is $s = 4\ \overline{AB}$.

## 1580 SLIDER-CRANK MECHANISM OF A TWO-CYLINDER ENGINE

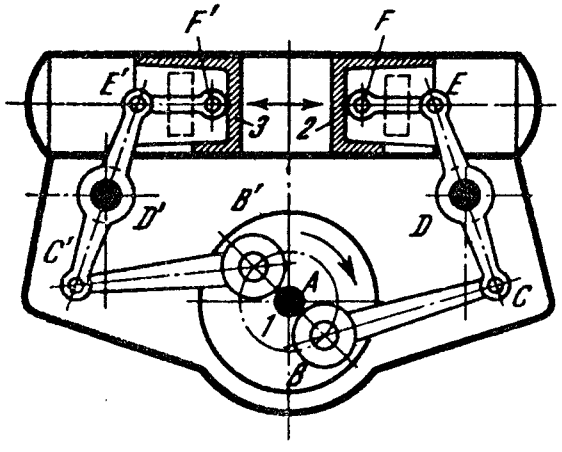
SC PM




Connecting rods *2* and *3* are connected by turning pairs *B* to crank *1*, designed as a heavy flywheel. The axes of the cylinders are located on a common vertical. In this engine the forces of inertia of the masses of the links are partly counterbalanced.

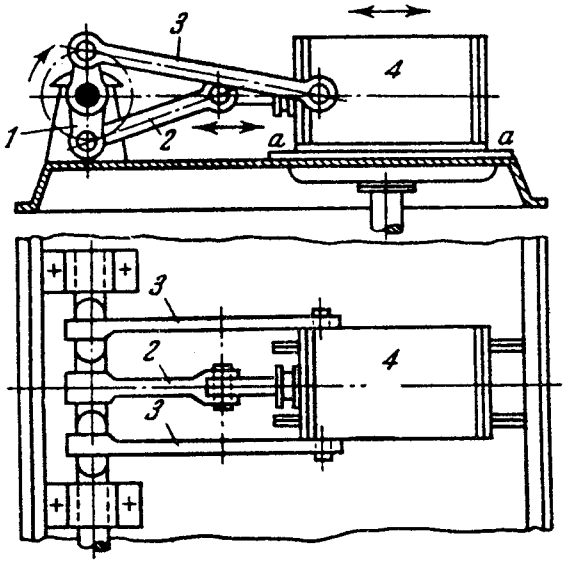
## 1581 SLIDER-CRANK MECHANISM OF A TWO-CYLINDER OPPOSED-PISTON ENGINE

SC PM



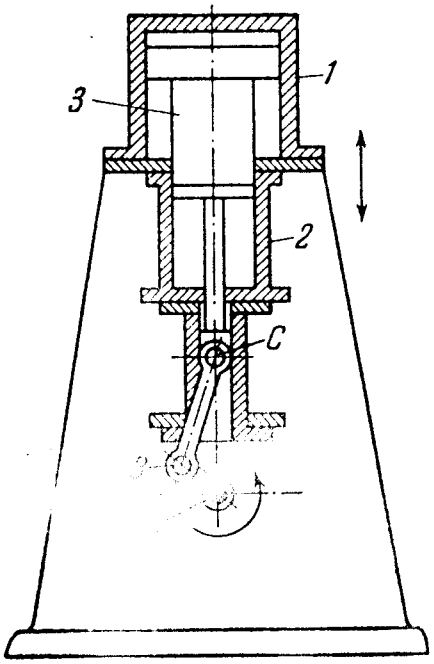

The lengths of the links comply with the conditions: $\overline{AB} = \overline{AB'}$, $\overline{BC} = \overline{B'C'}$, $\overline{CD} = \overline{C'D'}$, $\overline{DE} = \overline{D'E'}$ and $\overline{EF} = \overline{E'F'}$. Points *B* and *B'*, and *D* and *D'* are symmetrically located as shown. When crank *1* rotates about fixed axis *A*, pistons *2* and *3* travel in opposite directions.

| 1582 | SLIDER-CRANK MECHANISM OF A SLIDING CYLINDER ENGINE | SC PM |
|---|---|---|




Cylinder *4* is linked by connecting rods *3* to three-throw crankshaft *1*. Connecting rod *2* is driven by the piston. In operation cylinder *4* reciprocates, sliding along guides *a-a*.

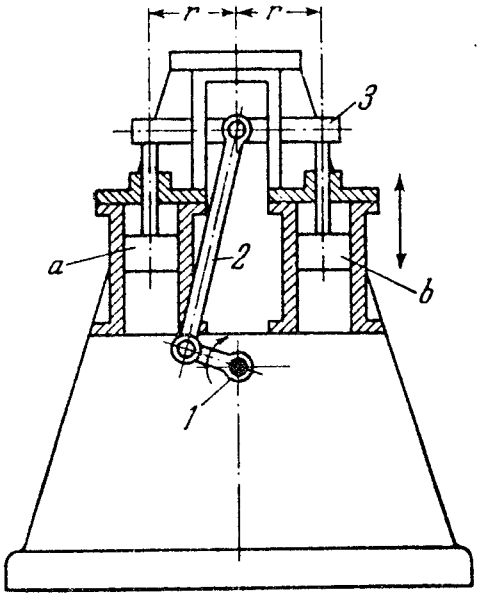
| 1583 | SLIDER-CRANK MECHANISM OF A TWO-STAGE COMPRESSOR | SC PM |
|---|---|---|




Cylinders *1* and *2* have different diameters. Piston *3* is designed as a single compound piston.

## 1584 SLIDER-CRANK MECHANISM OF A MULTIPLE-CYLINDER ENGINE

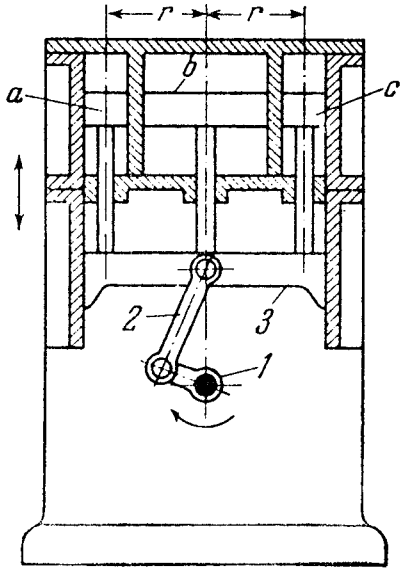
SC PM




Rigidly secured to slider *3* are the rods of pistons *a* and *b*. The axes of the cylinders are located on a circle of radius *r*. The maximum number of cylinders is determined by the space available on the base.

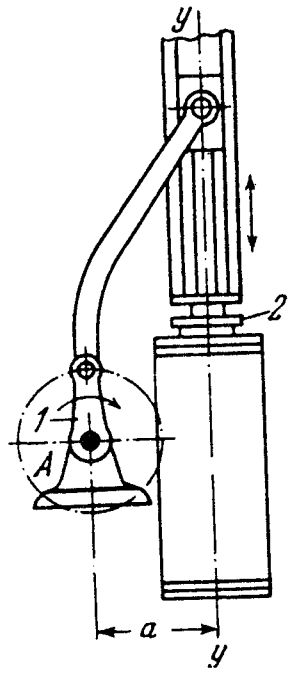
## 1585 SLIDER-CRANK MECHANISM OF AN ENGINE WITH SUPPLEMENTARY PISTONS

SC PM



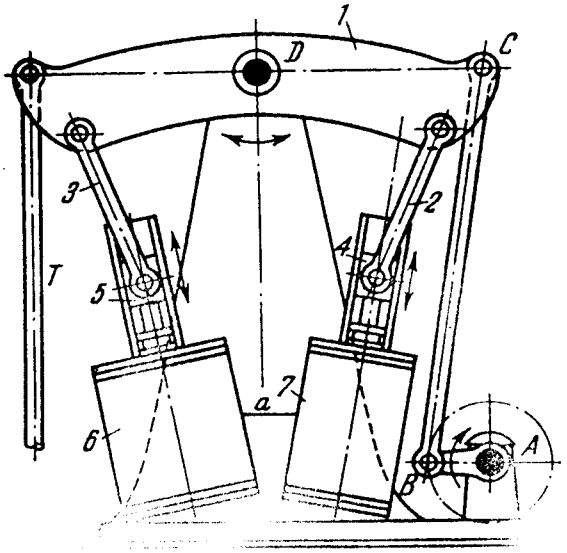

Rigidly secured to slider *3* are the rods of the main piston *b* and the supplementary pistons *a* and *c*. The axes of the supplementary cylinders are located on a circle of radius *r*. The maximum number of cylinders is determined by the space available on the base.

| 1586 | OFFSET SLIDER-CRANK MECHANISM OF AN ENGINE | SC PM |
|---|---|---|



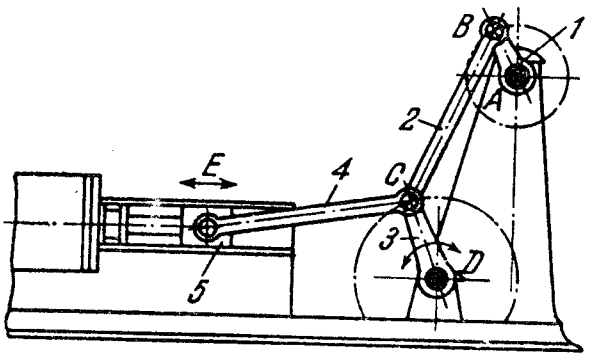

Axis *y-y* of the cylinder does not pass through fixed axis *A* of rotation of crank *1*. Offset *a* is greater than the radius of crank *1*. The times of the forward and return strokes of piston *2* are unequal.

| 1587 | FOUR-BAR LINKAGE OF AN ENGINE WITH TWO ATTACHED CONNECTING RODS AND SLIDERS | SC PM |
|---|---|---|



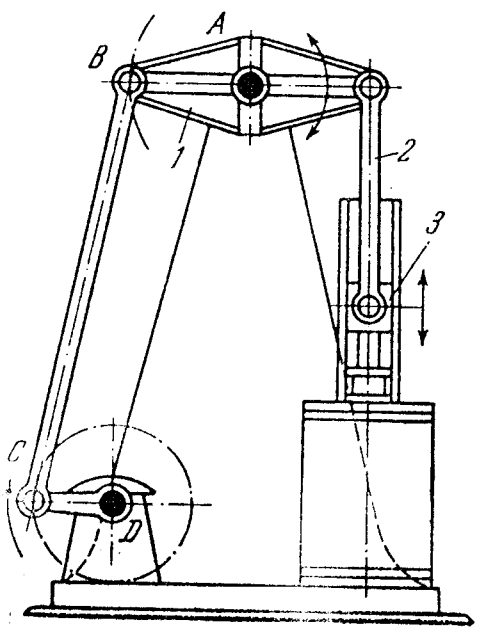

Tie-rod *T* is connected to the driving mechanism of the auxiliary devices. Connected to rocker arm *1* of four-bar linkage *ABCD* are connecting rods *2* and *3* which are connected, in turn, by turning pairs to sliders *4* and *5*. The axes of cylinders *6* and *7* are symmetrical with respect to vertical axis *Da*, making equal angles with this axis.

| 1588 | FOUR-BAR LINKAGE OF AN ENGINE WITH ATTACHED CONNECTING ROD AND SLIDER | SC PM |
|---|---|---|



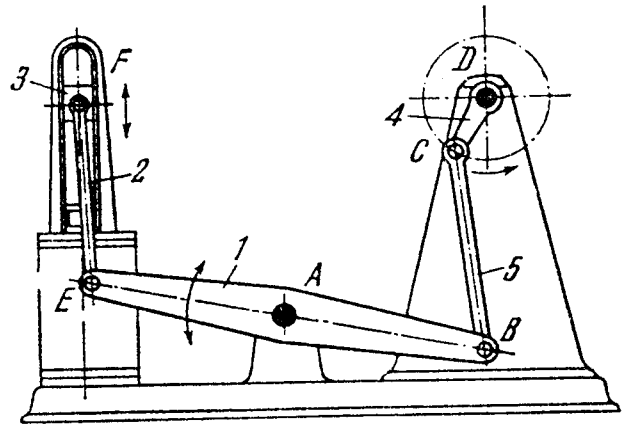

Connecting rod *4* is connected by turning pairs *E* and *C* to slider *5* and to rocker arm *3* of four-bar linkage *ABCD*. The lengths of the links comply with the condition: $\overline{AB} + \overline{AD} = \overline{BC} + \overline{CD}$. Crank *1* makes two complete revolutions about fixed axis *A* to each full stroke (back and forth) of the piston.

| 1589 | FOUR-BAR LINKAGE OF AN ENGINE WITH ATTACHED CONNECTING ROD AND SLIDER | SC PM |
|---|---|---|



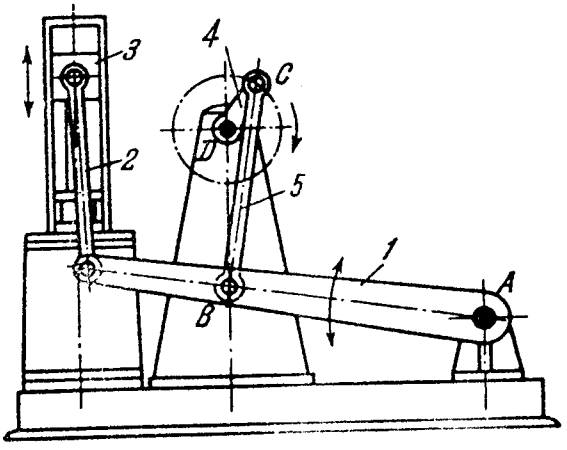

Connecting rod *2* is connected by turning pairs to slider *3* and to rocker arm *1* of four-bar linkage *ABCD*. Rocker arm *1* oscillates about fixed axis *A*, reciprocating the piston through connecting rod *2*. The lengths of the links of linkage *ABCD* are selected so that lengths $\overline{AB}$ plus $\overline{BC}$ are only slightly more than lengths $\overline{AD}$ plus $\overline{DC}$. As a result, rocker arm *1* has a large angle of swing, providing a long stroke for slider *3*. Rocker arm *1* is balanced with respect to axis *A*.

| 1590 | FOUR-BAR LINKAGE OF AN ENGINE WITH ATTACHED CONNECTING ROD AND SLIDER | SC PM |
|---|---|---|




Connecting rod *2* is connected by turning pairs *F* and *E* to slider *3* and to rocker arm *1* of four-bar linkage *ABCD*. Reciprocation of slider *3* is transformed by connecting rods *2* and *5*, and rocker arm *1* into rotation of crank *4* about fixed axis *D*. Rocker arm *1* oscillates about fixed axis *A*. The lengths of the links comply with the condition: $\overline{AD} + \overline{DC} < \overline{CB} + \overline{AB}$. Rocker arm *1* is balanced with respect to axis *A*.

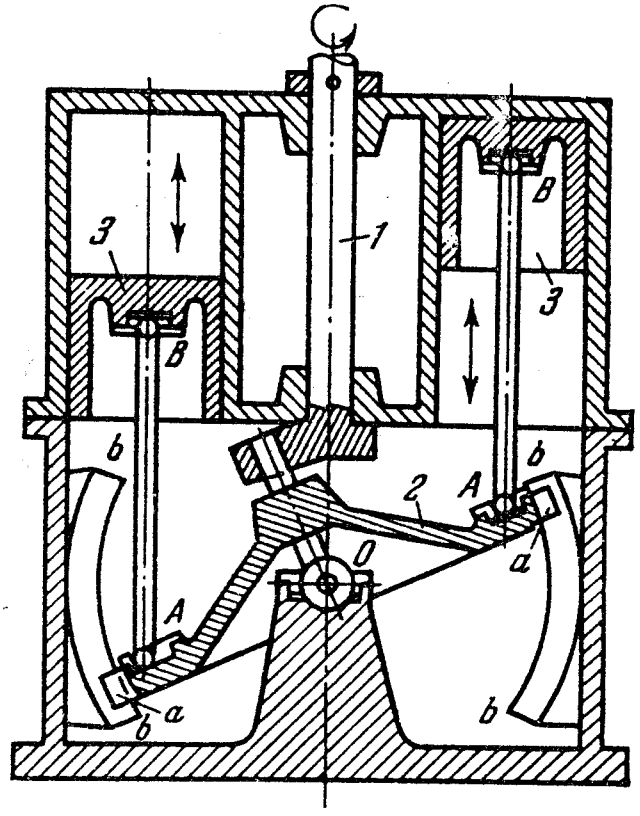
| 1591 | FOUR-BAR LINKAGE OF AN ENGINE WITH ATTACHED CONNECTING ROD AND SLIDER | SC PM |
|---|---|---|




Connecting rod *2* is connected by turning pairs to slider *3* and to rocker arm *1* of four-bar linkage *ABCD*. Reciprocation of slider *3* is converted by connecting rods *2* and *5*, and rocker arm *1* into rotation of crank *4* about fixed axis *D*. Rocker arm *1* oscillates about fixed axis *A*. The lengths of the links comply with the condition: $\overline{AD} + \overline{DC} < \overline{CB} + \overline{AB}$. Special counterweights are required to balance rocker arm *1* with respect to axis *A*.

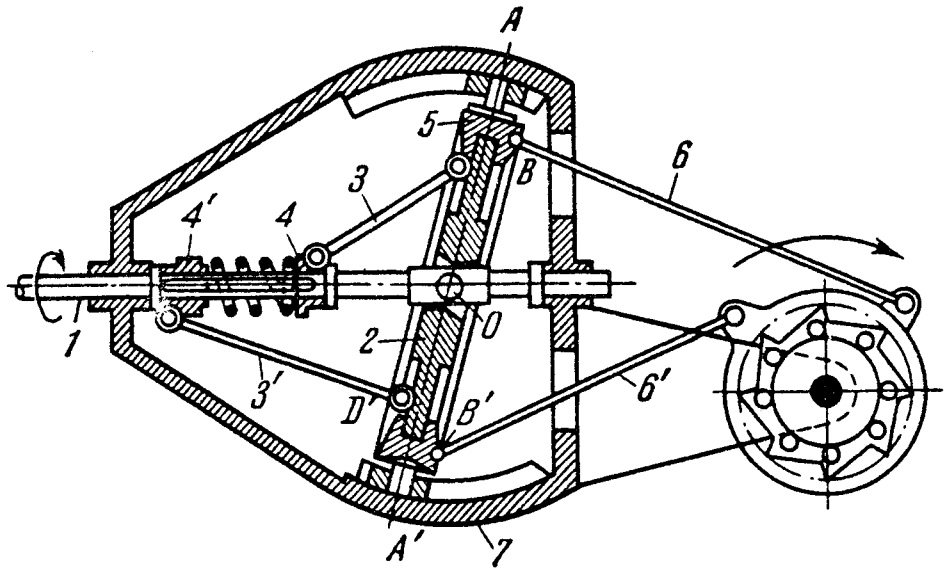
# 7· WOBBLE PLATE MECHANISMS (1592 through 1600)

| 1592 | SLIDER-CRANK WOBBLE PLATE MECHANISM | SC WP |
|---|---|---|



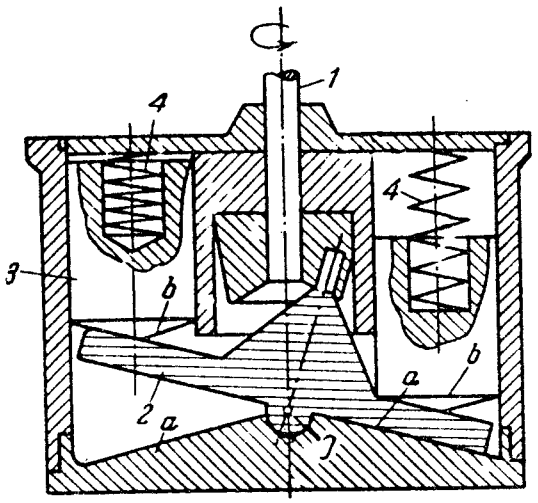

Wobble plate *2* runs on a spherical bearing with its centre at point *O*. Trunnions *a* of plate *2* slide along circular guides *b*-*b*. Rotation of shaft *1* is converted by wobble plate *2* into reciprocation of pistons *3*. Spherical pairs are provided at points *A* and *B*.

| 1593 | SLIDER-CRANK SPHERICAL WOBBLE PLATE MECHANISM WITH A RATCHET WHEEL | SC WP |
|---|---|---|



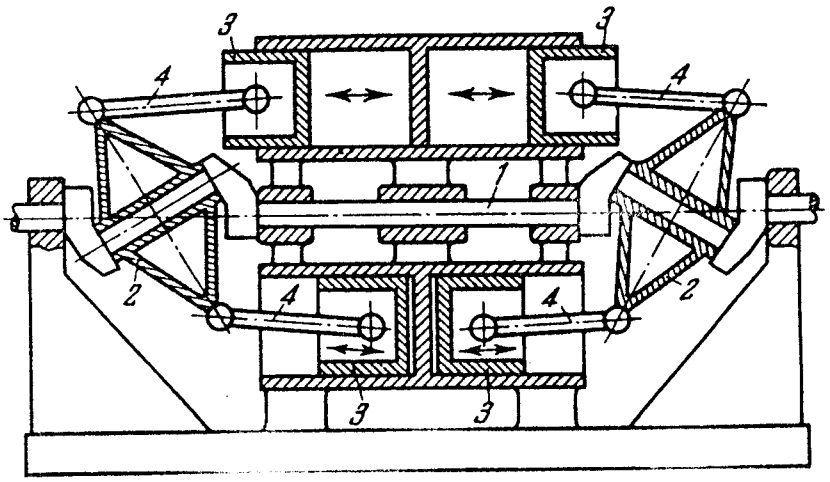

Wobble plate *2* is connected by a turning pair to shaft *1* and is enclosed by ring *5* which has pins *A* and *A'* sliding in fixed guides of the housing. Tie-rods *3* and *3'* are connected by turning pairs to wobble plate *2* and to sleeves *4* and *4'*. The sleeves rotate together with shaft *1*, being mounted on keys. A spring is mounted on shaft *1* between the sleeves. When shaft *1* rotates, wobble plate *2* rotates in ring *5* which oscillates with respect to point *O*. At points *B* and *B'* ring *5* is connected by spherical pairs to tie-rods *6* and *6'* which, in turn, are connected to a ratchet device and drive its shaft. As long as the forces of resistance exerted by tie-rods *6* and *6'* are counterbalanced by the tension of the spring between sleeves *4* and *4'*, the angle made by ring *5* and wobble plate *2* with shaft *1* remains constant. When the load increases on the shaft of the ratchet device, the spring between sleeves *4* and *4'* is compressed, increasing the angle between the plane of plate *2* and shaft *1* and thereby automatically reducing the transmission ratio between shaft *1* and the shaft of the ratchet device.

| 1594 | SLIDER-CRANK WOBBLE PLATE MECHANISM | SC WP |
|---|---|---|



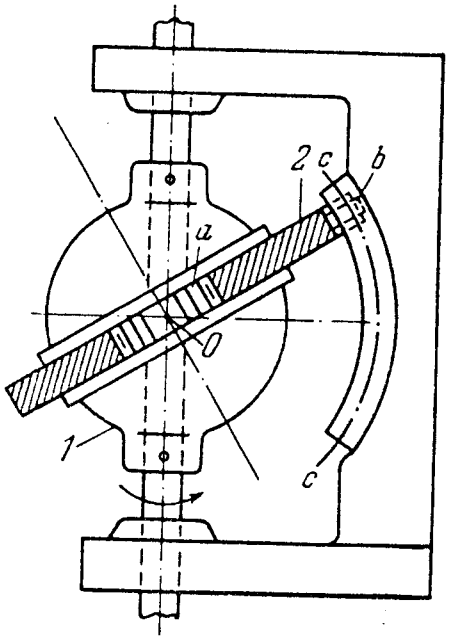

Wobble plate *2* has a spherical thrust bearing with its centre at point *O*. Plate *2* rolls around conical surface *a*. Pistons *3* end in cones *b* which slide along wobble plate *2*. By means of the wobble plate, rotation of shaft *1* is converted into reciprocation of pistons *3*. The pistons are loaded by springs *4* to keep them in contact with wobble plate *2*.

| 1595 | SLIDER-CRANK DOUBLE WOBBLE PLATE MECHANISM | SC WP |
|---|---|---|



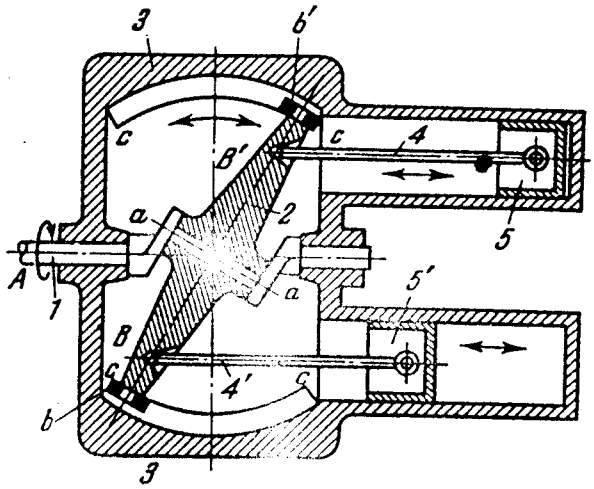

The mechanism consists of two wobble plates *2* driven by common shaft *1*. Connecting rods *4* are connected by spherical pairs to plates *2* and to pistons *3*. By means of the wobble plates, rotation of shaft *1* is converted into reciprocation of pistons *3*.

| 1596 | SLIDER-CRANK WOBBLE PLATE MECHANISM | SC WP |
|---|---|---|



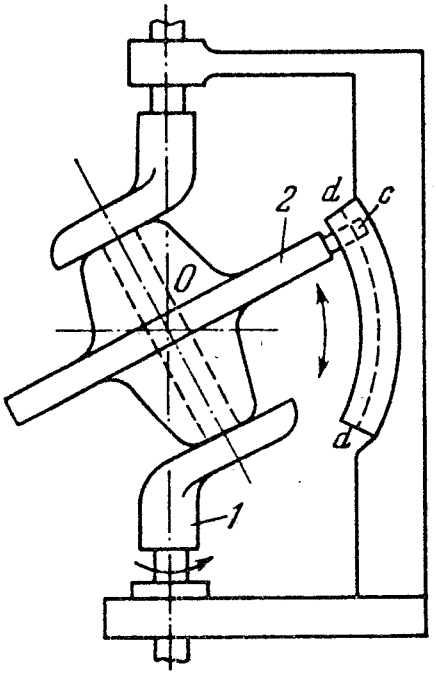

Crank *1* is rigidly secured to ring *a* on which wobble plate *2* is freely mounted. Pin *b* of plate *2* slides along circular guides *c-c* whose centre is at point *O*. When crank *1* rotates, wobble plate *2* oscillates about point *O*.

| 1597 | SLIDER-CRANK SPHERICAL WOBBLE PLATE MECHANISM | SC WP |
|---|---|---|



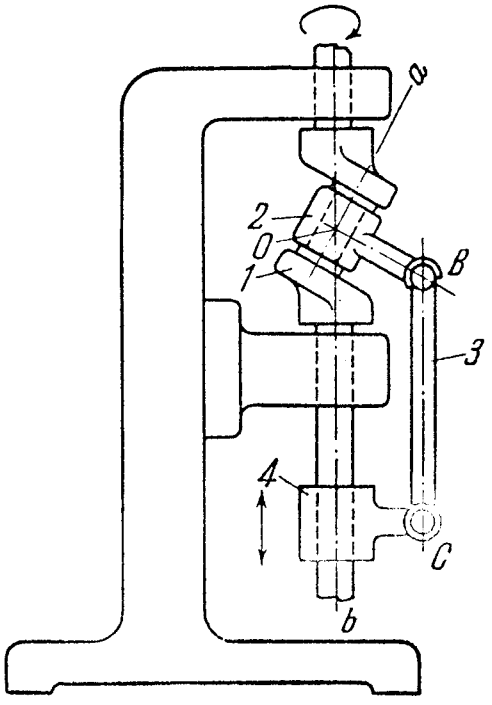

C... ates about fixed axis *A*. Wobble plate ... mounted perpen... ular to axis *a-a*. Rollers *b* and *b'* roll al... g circular guides *c-c* of housing *3*. Connecting rods *4* and *4'* ar... connected by spherical pairs *B'* and *B* to wobble plate *2* and by turning pairs to pistons *5* and *5'*. When crank *1* rotates, plate *2* oscillates and pistons *5* and *5'* reciprocate in opposite directions.

| 1598 | SLIDER-CRANK WOBBLE PLATE MECHANISM | SC WP |
|---|---|---|



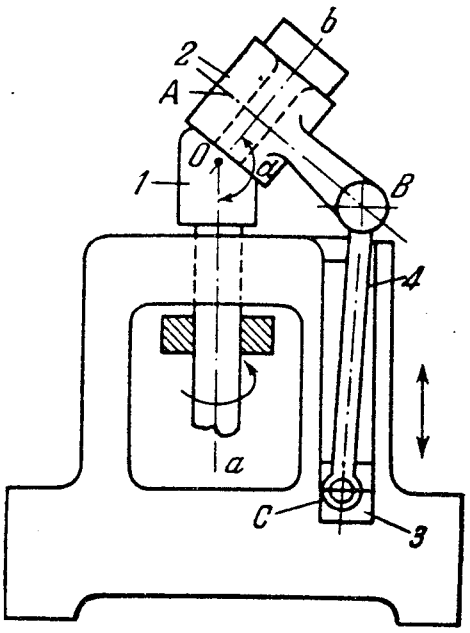

Wobble plate *2* has pin *c* which slides along fixed circular guides *d-d* whose centre is at point *O*. When crank *1* rotates, wobble plate *2* oscillates about point *O*.

| 1599 | SLIDER-CRANK WOBBLE PLATE MECHANISM | SC WP |
|---|---|---|




Wobble plate *2* turns about axes *Oa*, *Ob* and an axis perpendicular to the plane of the drawing. Connecting rod *3* is connected by spherical pair *B* to plate *2* and by turning pair *C* to link *4*. When crank *1* rotates, link *4* reciprocates along the axis of link *1*.

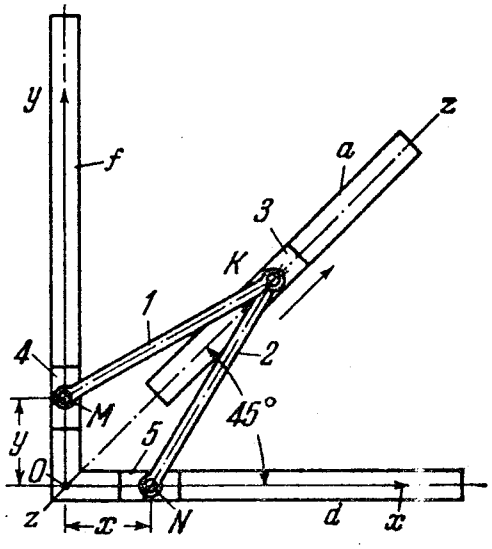
| 1600 | SLIDER-CRANK WOBBLE PLATE MECHANISM | SC WP |
|---|---|---|




Axes *Oa* and *Ob* of crank *1* and wobble plate *2* intersect at point *O* and have the angle $\alpha$ between them. Point *B* of wobble plate *2* travels along a circular arc of radius $\overline{AB}$. Thus, plate *2* turns about axes *Oa*, *Ob* and an axis perpendicular to the plane of the drawing. Connecting rod *4* is connected by spherical pair *B* to plate *2* and by turning pair *C* to slider *3*. When crank *1* rotates, slider *3* reciprocates.

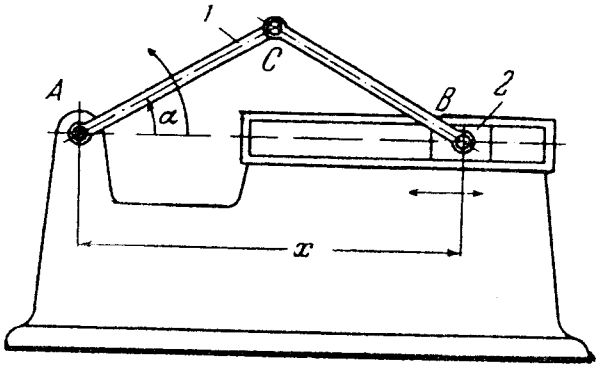
# 8. MECHANISMS FOR MATHEMATICAL OPERATIONS (1601 and 1602)

| 1601 | SLIDER-CRANK MECHANISM FOR PLOTTING EQUAL INTERCEPTS ON COORDINATE AXES | SC MO |
|---|---|---|




The lengths of the links comply with the condition: $\overline{MK} = \overline{NK}$. Slider 3 moves along fixed guide $a$ whose axis $Oz$ makes the angle 45° with axis $Ox$ of fixed guide $d$ along which slider 5 moves. Slider 4 moves along fixed guide $f$ whose axis $Oy$ is perpendicular to axis $Ox$. Links 1 and 2 are connected by turning pairs $M$ and $N$ to sliders 4 and 5, and by turning pairs $K$ to slider 3. When slider 3 moves along guide $a$, points $M$ and $N$ plot equal intercepts $y$ and $x$ along the coordinate axes.

| 1602 | SLIDER-CRANK SINE GENERATOR | SC MO |
|---|---|---|

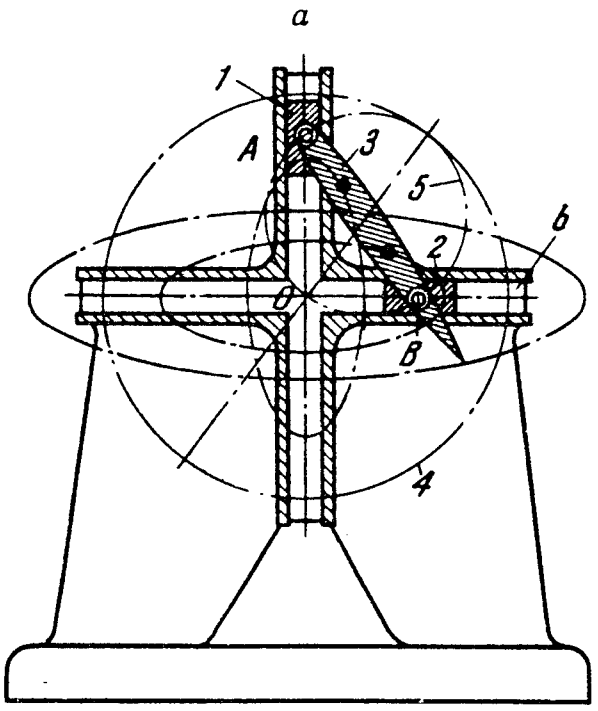



The lengths of the links comply with the condition: $\overline{AC} = \overline{CB} = l$. The axis of the guide of slider 2 passes through fixed axis $A$ of crank 1. When crank 1 is turned through angle $\alpha$, slider 2 is set to a distance from point $A$ equal to

$$x = 2l \cos \alpha = 2l \sin \left( \frac{\pi}{2} - \alpha \right).$$

# 9. MECHANISMS FOR GENERATING CURVES
## (1603 through 1624)

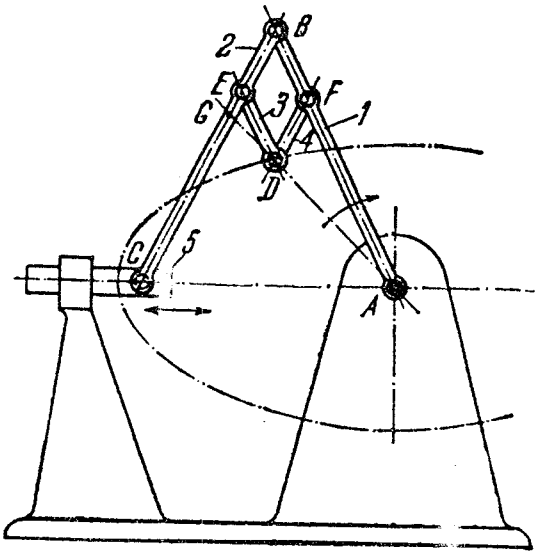
| 1603 | FOUR-BAR ELLIPSOGRAPH MECHANISM | SC<br>Ge |
|---|---|---|




Sliders *1* and *2* move along fixed guides *a* and *b* whose axes are perpendicular to each other. Points of link *3* describe ellipses with their centre at point *O* and with semiaxes whose lengths equal, respectively, the distances from the selected point to points *A* and *B*. The mechanism is equivalent to a mechanism consisting of two gears, *4* and *5*. If gear *4* of radius $\overline{AB}$ is fixed and gear *5* of radius $\overline{AB}/2$ is rolled inside gear *4* without slipping, then points of gear *5* describe the same ellipses as points of link *3* of the iniiial mechanism.

## 1604 SLIDER-CRANK ELLIPSOGRAPH MECHANISM WITH A PANTOGRAPH

SC Ge

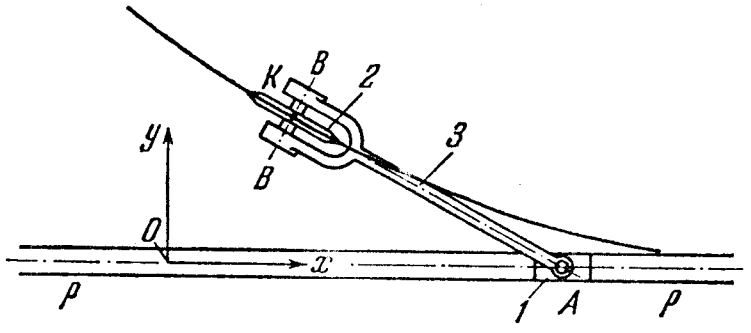



The lengths of the links comply with the conditions: $\overline{BC} = \overline{AB}$, $\overline{BF} = \overline{ED}$ and $\overline{BE} = \overline{FD}$. Links *1*, *2* and *5* form an ellipsograph. Any point of link *2* describes an ellipse. Links *1*, *2*, *3* and *4* form a pantograph. Therefore, point *D* describes an ellipse similar to the one described by point *G* of link *2*, the similarity factor being

$$k = \frac{\overline{AF}}{\overline{AB}}.$$

## 1605 FOUR-BAR MECHANISM FOR TRACING HUYGENS TRACTRICES

SC Ge




Slider *1* moves along fixed guides *p-p* and is connected by turning pair *A* to link *3*. Wheel *2* rotates about axis *B-B*. When slider *1* moves along guides *p-p*, wheel *2*, cutting into the surface of the drawing with its sharp edge, rolls along straight line *AK*. The envelope of the successive positions of straight line *AK* is a tractrix of Huygens with the equation

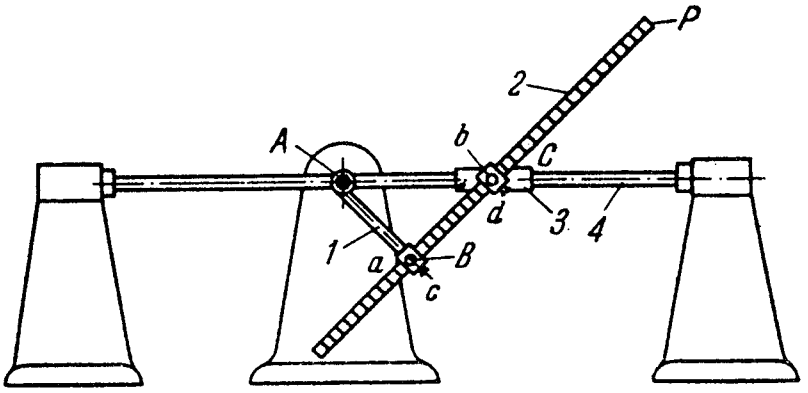
$$a + \sqrt{a^2 - y^2} = y e^{\frac{x - \sqrt{a^2 - y^2}}{a}}$$

where $a = \overline{AK}$

$e$ = base of natural logarithms.

## 1606 SLIDER-CRANK ELLIPSOGRAPH MECHANISM WITH LINK LENGTH ADJUSTMENT

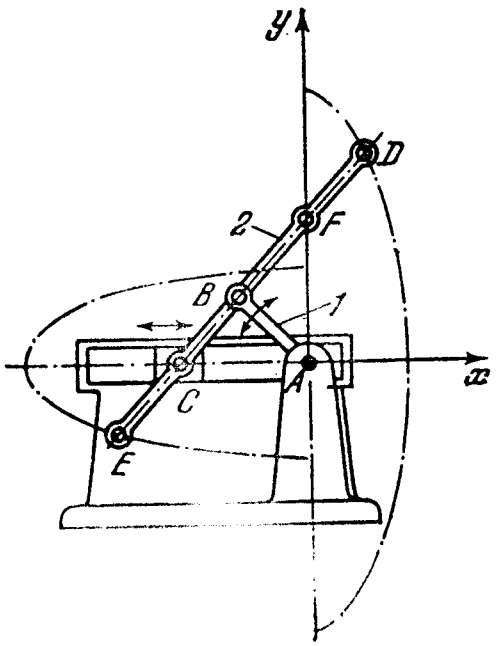
SC Ge




The lengths of the links comply with the condition: $\overline{AB} = \overline{BC}$. Link *2* is connected by turning pairs *B* and *C* to crank *1* and slider *3* which moves along fixed rod *4*. Link *2* can be clamped in various positions by means of screws *c* and *d*. When crank *1* rotates about fixed axis *A*, point *P* describes an ellipse whose parameters can be varied by changing the position of point *P*. This is done by means of clamping screws *c* and *d* at points *B* and *C*.

## 1607 SLIDER-CRANK ELLIPSOGRAPH MECHANISM

SC Ge




The lengths of the links comply with the condition: $\overline{AB} = \overline{BC} = \overline{BF}$. Point *F* of connecting rod *2* travels along axis *Ay*. Points *D* and *E* of connecting rod *2* describe ellipses with the equations

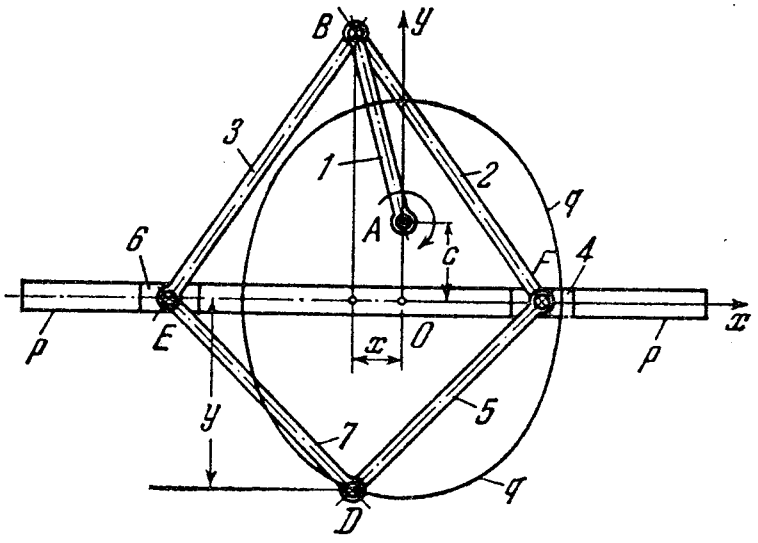
$$\frac{x^2}{\overline{FD}^2} + \frac{y^2}{\overline{CD}^2} = 1$$

and

$$\frac{x^2}{\overline{FE}^2} + \frac{y^2}{\overline{CE}^2} = 1.$$

The other points of connecting rod 2 also describe ellipses which are variously oriented with respect to axes *Ax* and *Ay*. Points lying on a circle of a diameter equal to $\overline{CF}$ describe straight lines passing through point *A* and, finally, point *B* describes a circle.

| 1608 | SOMOV SLIDER-CRANK MECHANISM FOR TRACING CASSINIAN OVALS | SC Ge |
|---|---|---|



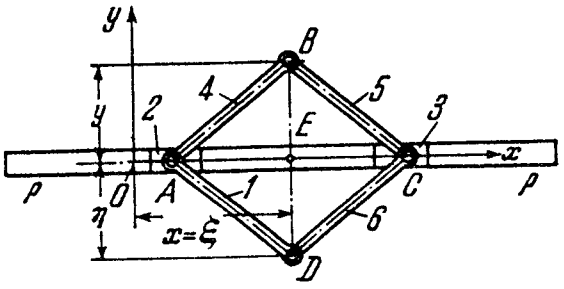

The lengths of the links comply with the conditions: $\overline{EB} = \overline{BF} = a$ and $\overline{ED} = \overline{DF} = b$. Figure $EBFD$ is a rhomboid linkage. Link *1* turns about fixed axis $A$ and is connected by turning pairs $B$ to links *2* and *3*. Links *2* and *3* are connected by turning pairs $F$ and $E$ to sliders *4* and *6* which move along fixed guides $p$-$p$ whose axis coincides with axis $Ox$. Links *5* and *7* are connected together by turning pair $D$ and to sliders *4* and *6* by turning pairs $F$ and $E$. When link *1* turns about axis $A$, point $D$ describes a Cassinian oval with the equation

$$(y^2 + x^2)^2 - 2c^2 (y^2 - x^2) = d^4 - c^4$$

where $d^4 = 4 (a^2 - b^2) c^2$
$a$, $b$ and $c$ = constant dimensions of the mechanism.
If $d = c$ then point $D$ describes a lemniscate of Bernoulli with the equation

$$(y^2 + x^2) - 2c^2 (y^2 - x^2) = 0.$$

| 1609 | DELONÉ SLIDER-CRANK REVERSER MECHANISM | SC Ge |
|---|---|---|

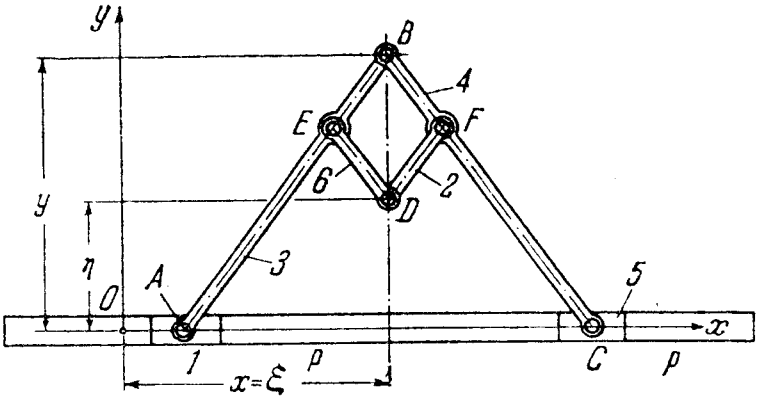



The lengths of the links comply with the condition: $\overline{AB} = \overline{BC} = \overline{CD} = \overline{DA}$, i.e. figure $ABCD$ is a rhombus linkage. Links *1* and *4* are connected by turning pairs $A$ to slider *2* and by turning pairs $D$ and $B$ to links *6* and *5* which, in turn are connected by turning pairs $C$ to slider *3*. Sliders *2* and *3* move along fixed guides $p$-$p$. When point $B$ is moved along a curve with the equation $F(x, y) = 0$, then point $D$ describes curve $P(\xi, \eta) = 0$. Coordinates $x$, $y$, $\xi$ and $\eta$ are related by the conditions:

$$x = \xi \quad \text{and} \quad y = -\eta.$$

Hence the mechanism can trace a mirror image of a curve with respect to axis $Ox$, or it can be used to trace two portions of the same curve which are symmetrical with respect to some straight line.

| 1610 | DELONÉ SLIDER-CRANK PROJECTOR MECHANISM | SC Ge |
|---|---|---|

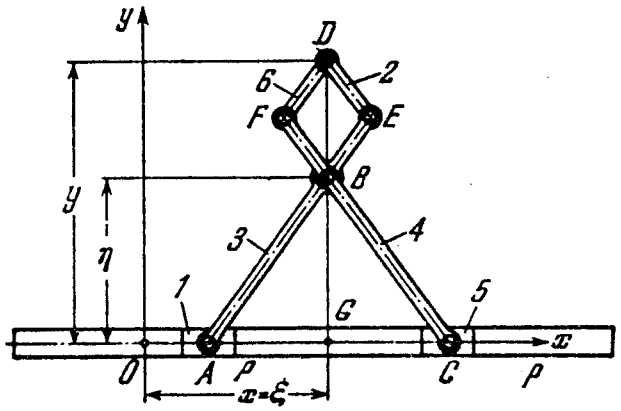



The lengths of the links comply with the conditions: $\overline{AB} = \overline{BC} = m$ and $\overline{EB} = \overline{BF} = \overline{FD} = \overline{DE} = n$. Figure $EBFD$ is a rhombus linkage. Links *3* and *4* are connected by turning pairs $A$ and $C$ to sliders *1* and *5* which move along fixed guides $p$-$p$. When point $B$ is moved along a curve with the equation $F(x, y) = 0$, point $D$ describes curve $P(\xi, \eta) = 0$. Coordinates $x$, $y$, $\xi$ and $\eta$ are related by the conditions:

$$x = \xi \quad \text{and} \quad y = k\eta$$

where $k = \dfrac{m - 2n}{m} = \text{const}$. Curve $P(\xi, \eta) = 0$, described by point $D$, is a projection of curve $F(x, y) = 0$ on a plane making an angle $\varphi$ with the plane of the drawing and where $\cos \varphi = k$.

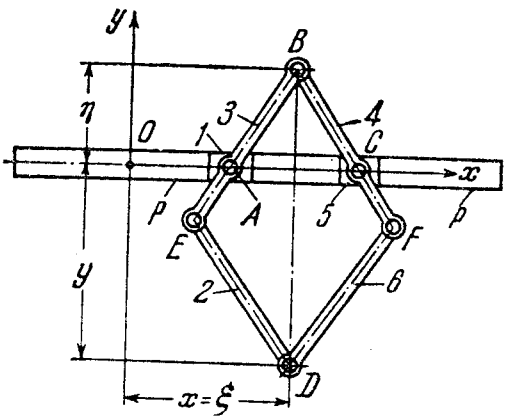
| 1611 | DELONE SLIDER-CRANK PROJECTOR MECHANISM | SC Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AE} = \overline{CF} = m$ and $\overline{ED} = \overline{DF} = \overline{EB} = \overline{BF} = n$. Figure $EBFD$ is a rhombus linkage. Links *3* and *4* are connected by turning pairs $A$ and $C$ to sliders *1* and *5* which move along fixed guides $p$-$p$. When point $D$ is moved along a curve with the equation $F(x, y) = 0$, point $B$ describes curve $P(\xi, \eta) = 0$. Coordinates $x$, $y$, $\xi$ and $\eta$ are related by the conditions

$$x = \xi \quad \text{and} \quad y = k\eta$$

$$\text{where } k = -\frac{m+n}{n-m} = \text{const.}$$

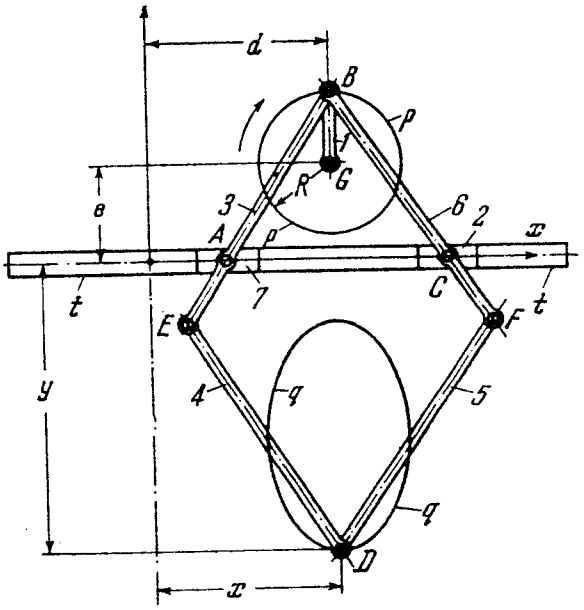



The lengths of the links comply with the conditions: $\overline{AE} = \overline{CF} = m$ and $\overline{EB} = \overline{BF} = \overline{FD} = \overline{DE} = n$. Figure $EBFD$ is a rhombus linkage. Links *3* and *4* are connected by turning pairs $A$ and $C$ to sliders *1* and *5* which move along fixed guides $p$-$p$. When point $D$ is moved along a curve with the equation $F(x, y) = 0$, point $B$ describes curve $P(\xi, \eta) = 0$. Coordinates $x$, $y$, $\xi$ and $\eta$ are related by the conditions:

$$x = \xi \quad \text{and} \quad y = k\eta$$

$$\text{where} \quad k = -\frac{m+n}{n-m} = \text{const.}$$

| 1613 | DELONE SLIDER-CRANK ELLIPSOGRAPH | SC Ge |
|---|---|---|

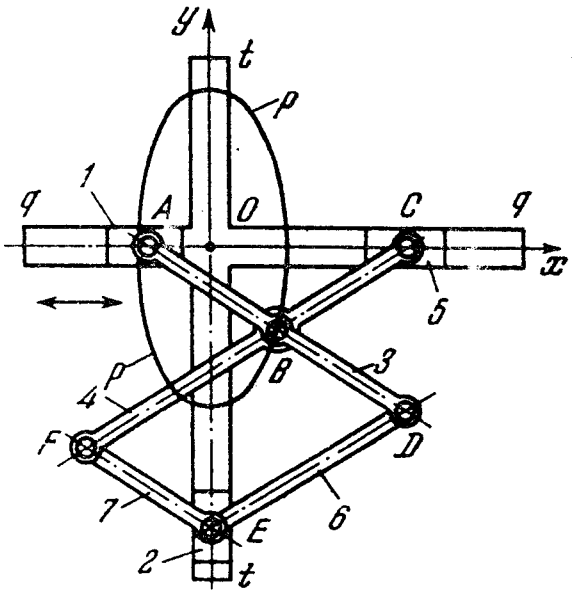



The lengths of the links comply with the conditions: $\overline{EB} = \overline{BF} = \overline{FD} = \overline{DE} = n$ and $\overline{AB} = \overline{BC} = m$. Figure $EBFD$ is a rhombus linkage. Link *1* rotates about fixed axis $G$ and is connected by turning pairs $B$ to links *3* and *6* which, in turn, are connected by turning pairs $A$ and $C$ to sliders *7* and *2*. Sliders *7* and *2* move along fixed guides $t$-$t$. Links *4* and *5* are connected by turning pairs $E$ and $F$ to links *3* and *6* and by turning pair $D$ to each other. When link *1* rotates about axis $G$, point $D$ describes ellipse $q$-$q$ with the equation

$$k^2x^2 + y^2 - 2k^2ex - 2k\,dy + (k^2d^2 + k^2e^2 - R^2) = 0$$

where $k = -\dfrac{n+m}{n-m}$. The minor axis of ellipse $q$-$q$ equals the diameter of circle $p$-$p$ described by point $B$ of link *1*, and the major axis equals the diameter of circle $p$-$p$ multiplied by $k$.

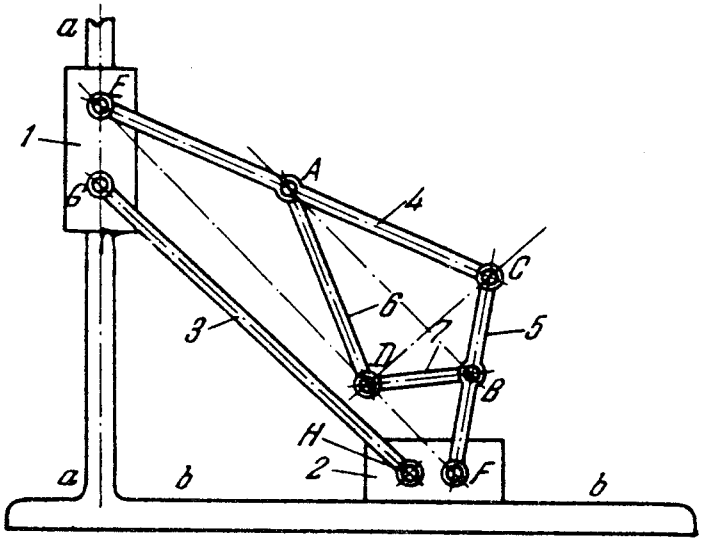
| 1614 | SOMOV SLIDER-CRANK ELLIPSOGRAPH MECHANISM | SC Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AB} = \overline{BC} = b$, $\overline{FB} = \overline{ED} = a$ and $\overline{BD} = \overline{FE} = c$. Figure $FBDE$ is a parallelogram. Sliders *1* and *5* move along fixed guides $q$-$q$ whose axis coincides with axis $Ox$, and are connected by turning pairs $A$ and $C$ to links *3* and *4*. Links *3* and *4* are connected by turning pair $B$ to each other and by turning pairs $D$ and $F$ to links *6* and *7*. Links *6* and *7* are connected by turning pairs $E$ to slider *2* which moves along fixed guides $t$-$t$ whose axis coincides with axis $Oy$. When slider *1* moves along guides $q$-$q$, point $B$ describes ellipse $p$-$p$ with the equation

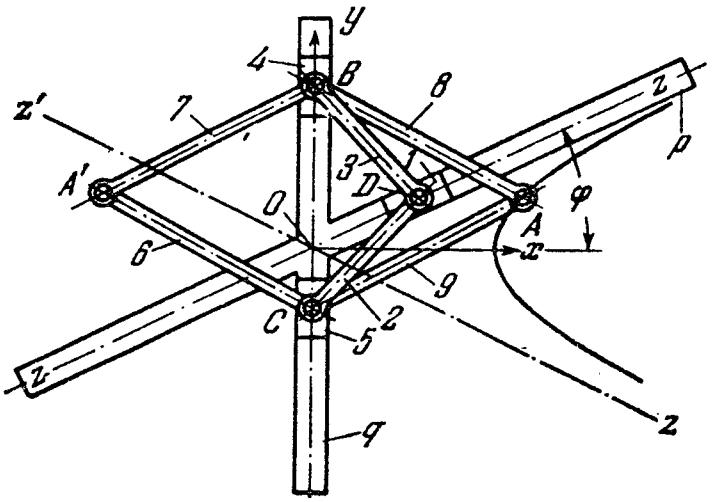
$$\frac{x^2}{(a-c)^2} + \frac{y^2}{b^2} = 1.$$

| 1615 | GERSHGORIN SLIDER-CRANK MECHANISM FOR DRAWING AIRPLANE WING SECTIONS | SC Ge |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{EA} = \overline{AC} = \overline{AD} = \overline{EC}/2$ and $\overline{FB} = \overline{BC} = \overline{BD} = \overline{CF}/2$. Sliders *1* and *2* move along fixed guides *a-a* and *b-b*. Link *3* is connected by turning pairs *G* and *H* to sliders *1* and *2*. Links *4* and *5* are connected by turning pairs *E* and *F* to sliders *1* and *2*, and by turning pairs *A* and *B* to links *6* and *7*. Point *D* is always on the straight line joining points *E* and *F*, line *AB* is parallel to line *EF* and line *CD* is perpendicular to line *EF*. When sliders *1* and *2* move along their guides (which are perpendicular to each other) point *D* describes the wing profile proposed by N. E. Zhukovsky.

| 1616 | DELONE SLIDER-CRANK MECHANISM FOR TRACING HYPERBOLAS | SC Ge |
|---|---|---|

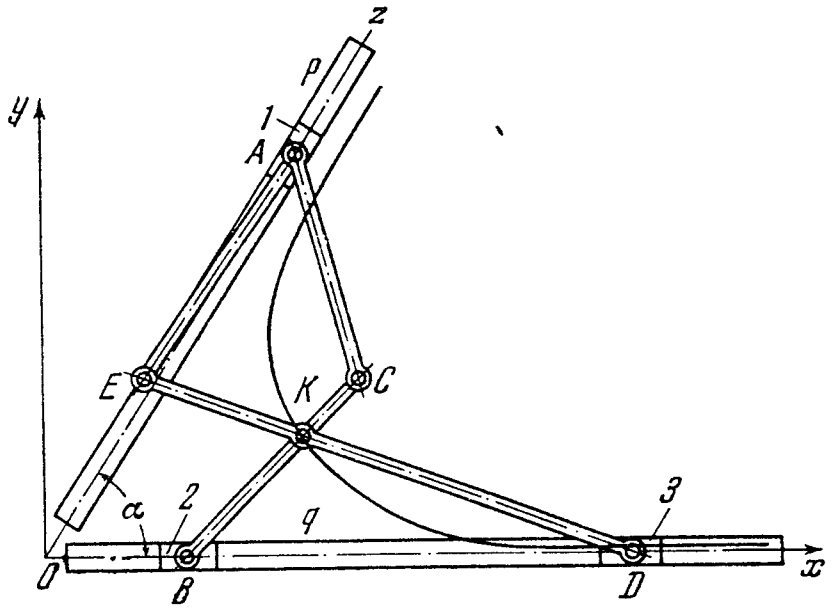



The lengths of the links comply with the conditions: $\overline{AB} = \overline{A'B} = \overline{A'C} = \overline{AC} = a$ and $\overline{BD} = \overline{DC} = b$. Thus, links *2*, *3*, *6*, *7*, *8* and *9* form an inversor. Slider *1* moves along fixed guides *p*. Sliders *4* and *5* move along fixed guides *q*. The angle between axes *Oy* and *Oz* of guides *q* and *p* is $90° - \varphi$. When slider *1* moves along guides *p*, points *A* and *A'* describe the two branches of a hyperbola whose asymptotes are the straight lines *z-z* and *z'-z'*. The equation of the hyperbola is

$$\frac{x^2}{a^2 - b^2} - \frac{y^2}{k^2 (a^2 - b^2)} = 1$$

where $k = \tan^2 \varphi$.

| 1617 | SOMOV SLIDER-CRANK MECHANISM FOR TRACING HYPERBOLAS | SC Ge |
|---|---|---|




The lengths of the links comply with the condition: $\overline{KE}^2 + \overline{CA}^2 = \overline{KC}^2 + \overline{EA}^2$. Slider *1* moves along fixed guides *p*. Sliders *2* and *3* move along fixed guides *q*. The angle between axes *Oz* and *Ox* of guides *p* and *q* is $\alpha$. When slider *1* moves along guides *p*, point *K* describes a hyperbola with the equation

$$a^2x^2 + y^2(1 + 2d) - 2a(1 + d)xy + c^2 - b^2 = 0$$

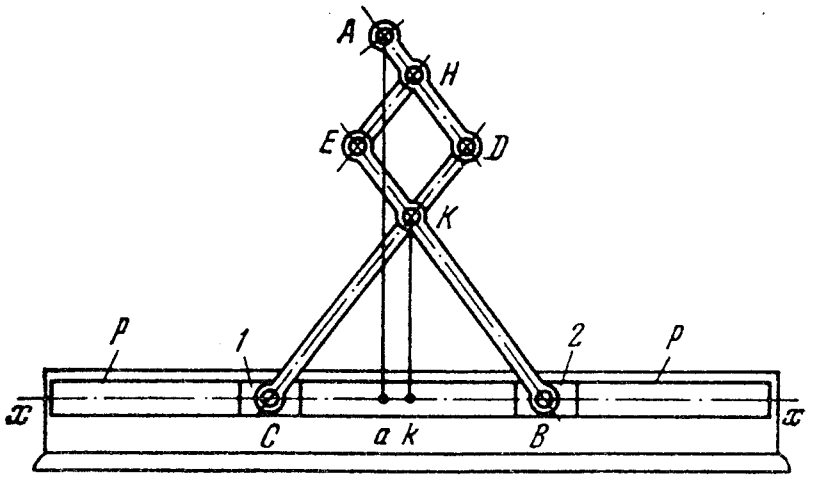
where $a = \tan\alpha$

$$d = \frac{\overline{KE}}{\overline{KD}} = \frac{\overline{KC}}{\overline{KB}}$$

$c = \overline{KE}$

$b = \overline{AE}$.

| 1618 | DELONÉ SLIDER-CRANK MECHANISM FOR DRAWING ISOMETRIC PROJECTIONS | SC Ge |
|---|---|---|



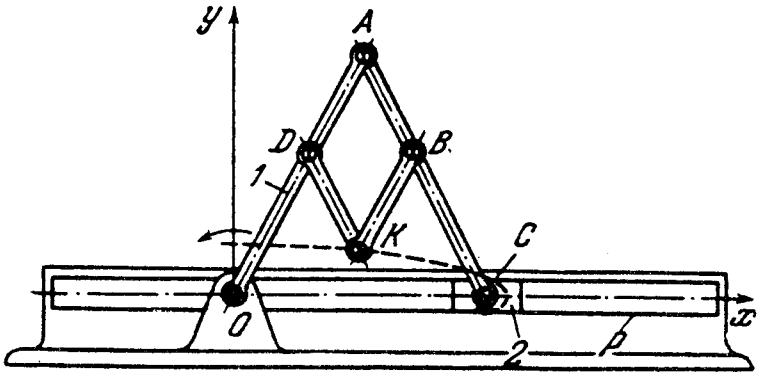

The lengths of the links comply with the conditions: $\overline{CD} = \overline{BE}$, $\overline{HE} = \overline{HD}$ and $\overline{EK} = \overline{KD}$. Sliders *1* and *2* move along fixed guides *p-p*. When point *A* is traced around a plane figure, point *K* describes the same figure with the scale changed in the direction perpendicular to axis *x-x*. The scale change factor is

$$\tau = \frac{\overline{Aa}}{\overline{Kk}} = \frac{\overline{AD} + \overline{DC}}{\overline{KC}}$$

There is no change in scale in the direction of axis *x-x*. At $\tau = \frac{1}{\sqrt{3}}$ conditions are complied with for an isometric projection.

## 1619 SLIDER-CRANK MECHANISM FOR TRACING ELLIPSES

SC Ge

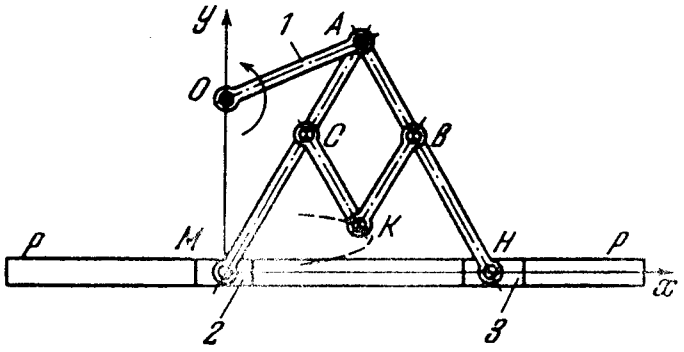



The lengths of the links comply with the conditions: $\overline{OA} = \overline{AC} = l$ and $\overline{AD} = \overline{DK} = \overline{KB} = \overline{BA} = a$. Crank *1* turns about fixed axis *O*. Slider *2* moves along fixed guides *p*. When crank *1* rotates about axis *O*, point *K* describes an ellipse with the equation

$$\frac{x^2}{l^2} + \frac{y^2}{(l+2a)^2} = 1.$$

## 1620 DELONÉ SLIDER-CRANK MECHANISM FOR TRACING ELLIPSES

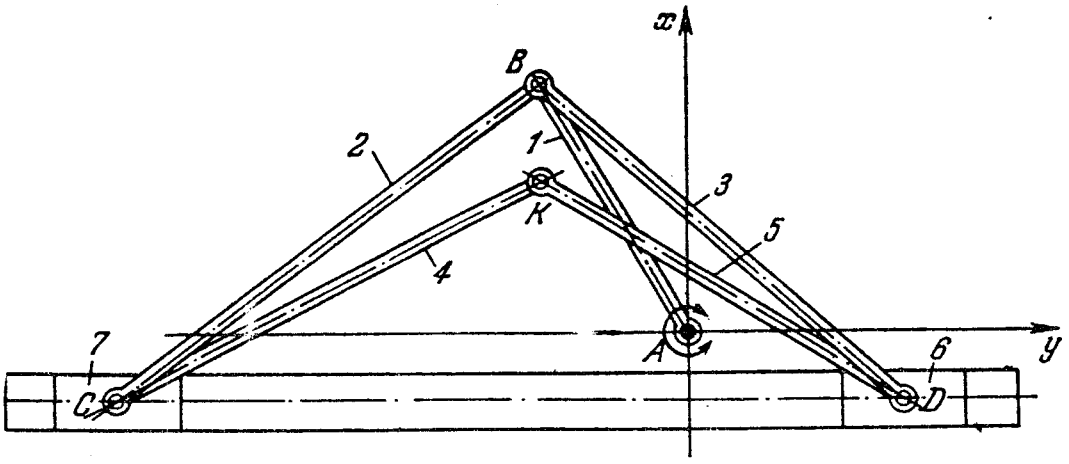
SC Ge




The lengths of the links comply with the conditions: $\overline{AM} = \overline{AN} = l$ and $\overline{AB} = \overline{BK} = \overline{KC} = \overline{CA} = a$. Crank *1* turns about fixed axis *O*. Sliders *2* and *3* move along fixed guides *p-p*. When crank *1* turns about axis *O*, point *K* describes an ellipse with a major semiaxis equal to length $\overline{OA}$ of crank *1* and a minor semiaxis equal to the length of the crank multiplied by the factor *m*:

$$m = 1 - 2\frac{a}{l}.$$

| 1621 | SOMOV SLIDER-CRANK MECHANISM FOR TRACING CASSINIAN OVALS | SC Ge |
|---|---|---|

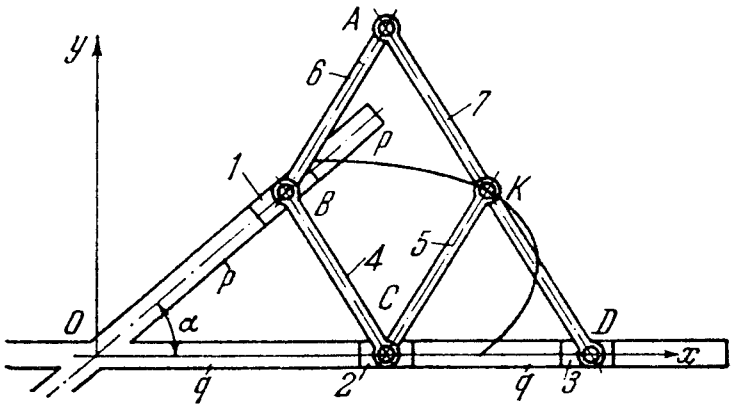



The lengths of the links comply with the conditions: $\overline{BC}^2 - \overline{KC}^2 = \overline{BD}^2 - \overline{DK}^2 = \overline{AB}^2$. Link *1* turns about fixed axis *A*. Links *2* and *3* are connected by turning pairs *B* to link *1* and by turning pairs *C* and *D* to sliders *7* and *6* which move along fixed guides. Links *4* and *5* are connected by turning pair *K* to each other and by turning pairs *C* and *D* to links *2* and *3*. When link *1* turns about axis *A*, point *K* describes a Cassinian oval with the equation

$$(x^2 + y^2 + a^2)^2 - 4a^2x^2 - 4a^2r^2 = 0$$

where $a = \overline{OA}$ and $r = \overline{AB}$. Points *K* and *B* lie on a straight line perpendicular to axis *Ay*.

| 1622 | SOMOV SLIDER-CRANK MECHANISM FOR TRACING ELLIPSES | SC Ge |
|---|---|---|

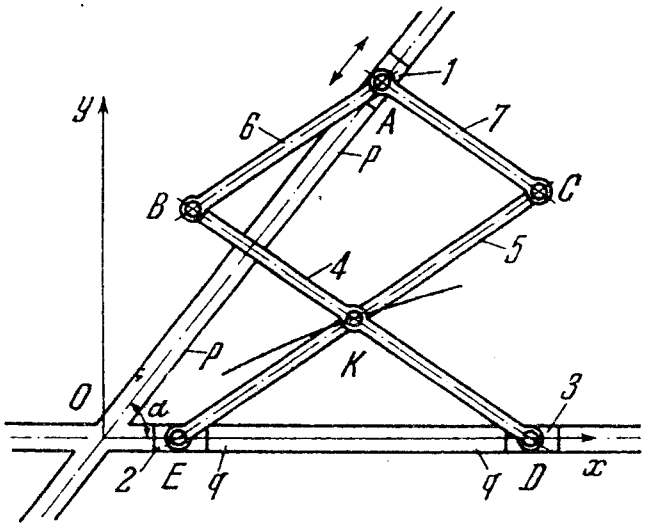



The lengths of the links comply with the conditions: $\overline{AB} = \overline{BC} = \overline{CK} = \overline{KA} = \overline{KD} = l$. Slider *1* moves along fixed guides *p-p*. Sliders *2* and *3* move along fixed guides *q-q* whose axis makes the angle $\alpha$ with the axis of guides *p-p*. Links *4* and *5* are connected by turning pairs *C* to slider *2*. Link *7* is connected by turning pairs *D*, *K* and *A* to slider *3* and to links *5* and *6*. Links *4* and *6* are connected by turning pairs *B* to link *1*. When slider *1* moves along guides *p-p* point *K* describes an ellipse with the equation

$$4a^2x^2 + (1 + a^2)\,y^2 - 4axy - 4a^2l^2 = 0$$

where $a = \tan\alpha$.

| 1623 | SOMOV SLIDER-CRANK MECHANISM FOR TRACING ELLIPSES | SC Ge |
|---|---|---|

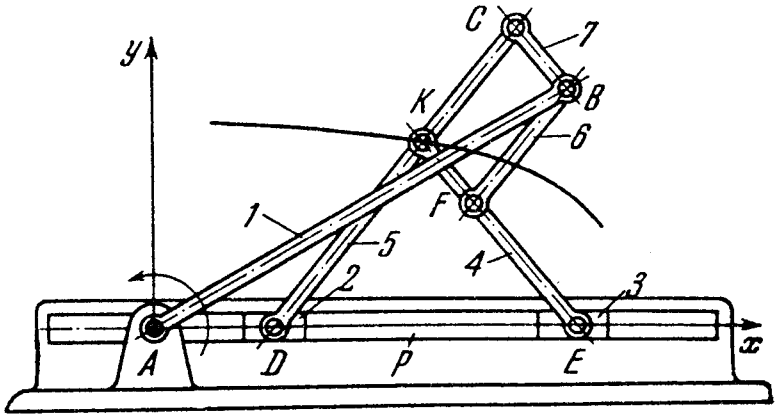



The lengths of the links comply with the conditions: $\overline{EK} = \overline{KD} = l$, $\overline{KB} = \overline{CA} = q_2 l$ and $\overline{KC} = \overline{BA} = q_1 l$, where $q_1$ and $q_2$ are arbitrary dimensionless factors. Slider *1* moves along fixed guides *p-p*. Sliders *2* and *3* move along fixed guides *q-q* whose axis makes the angle $\alpha$ with the axis of guides *p-p*. Links *4* and *5* are connected by turning pairs *D* and *E* to sliders *3* and *2*, and by turning pairs *B* and *C* to links *6* and *7*. Links *6* and *7* are connected by turning pairs *A* to slider *1*. Links *4* and *5* are connected together by turning pair *K*. When slider *1* moves along guides *p-p*, point *K* describes an ellipse with the equation

$$ax^2 + [(1 + q_1 + q_2)^2 + a^2 (q_2 - q_1)^2]\, y^2 - $$
$$-2a (1 + q_1 + q_2)\, xy - a^2 (q_2 - q_1)^2\, l = 0$$

where $a = \tan \alpha$.

| 1624 | SOMOV SLIDER-CRANK MECHANISM FOR TRACING ELLIPSES | SC Ge |
|---|---|---|

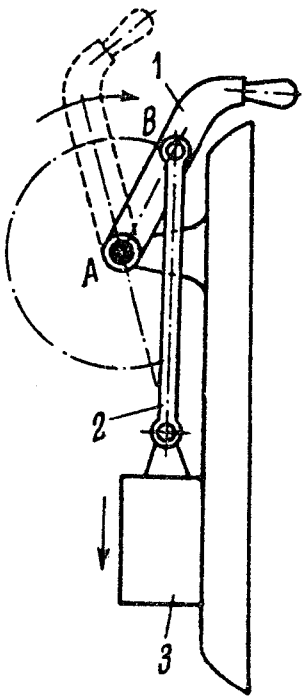



The lengths of the links comply with the conditions: $\overline{DK} = \overline{KE} = a$, $\overline{KC} = \overline{FB} = c$, $\overline{KF} = \overline{CB} = b$ and $\overline{AB} = a + b + c$. Crank *1* turns about fixed axis *A* and is connected by turning pairs *B* to links *6* and *7*. Sliders *2* and *3* move along fixed guides *p*. Links *5* and *4* are connected by turning pairs *D* and *E* to sliders *2* and *3*, and by turning pairs *C* and *F* to links *7* and *6*. Links *5* and *4* are connected together by turning pair *K*. When crank *1* turns about axis *A*, point *K* describes an ellipse with the equation

$$\frac{x^2}{(a-2b)^2} + \frac{y^2}{a^2} = 1.$$

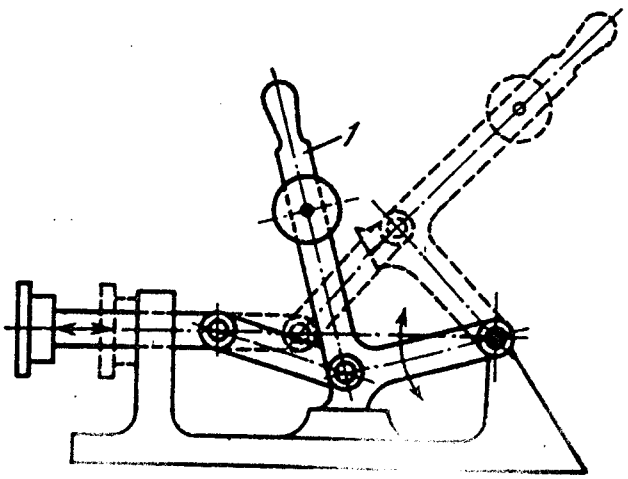
# 10. STOP, DETENT AND LOCKING MECHANISMS (1625 through 1628)

| 1625 | SLIDER-CRANK LOCKING LEVER MECHANISM | SC SD |
|---|---|---|



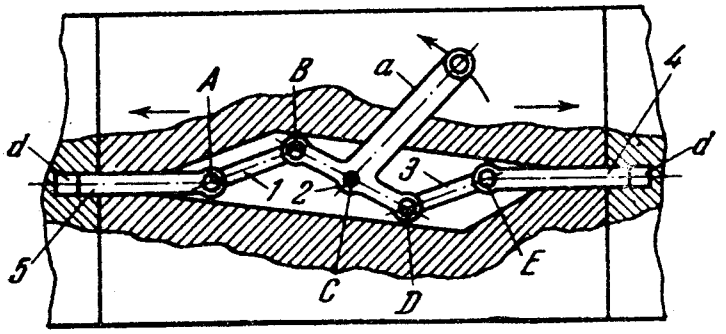

To lock lever *1* it is turned clockwise about fixed axis *A* from the position shown by dash lines to that shown by continuous lines. In the initial position the axes of crank *1* and connecting rod *2* coincide.

| 1626 | SLIDER-CRANK LOCKING LEVER MECHANISM | SC SD |
|---|---|---|



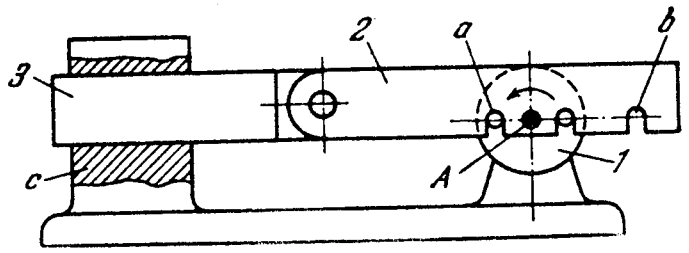

Lever *1* is shown in the closed position by continuous lines and in the open (idle) position by dash lines.

| 1627 | SLIDER-CRANK DOUBLE LOCK MECHANISM | SC SD |
|---|---|---|




When lever *a* is turned counterclockwise, the axes of links *1*, *2* and *3* will be located on a single straight line, i.e. points *A*, *B*, *C*, *D* and *E* will lie on a single straight line. At this, links *4* and *5* (the bolts) enter the corresponding recesses *d* up to the stops.

| 1628 | SLIDER-CRANK LOCK MECHANISM | SC SD |
|---|---|---|

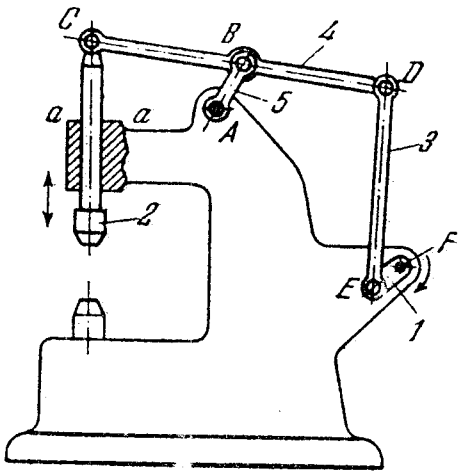



Link *1* turns about fixed axis *A* and has pins *a*. Slider *3* is the bolt of the lock and slides in fixed guide *c*. When link *1* is turned counterclockwise, connecting rod *2* advances slider *3*, closing the lock. In the closed position, left pin *a* enters slot *b*.

# 11. HAMMER, PRESS AND DIE MECHANISMS (1629 through 1633)

## 1629 SIX-BAR SLIDER-CRANK POWER HAMMER MECHANISM

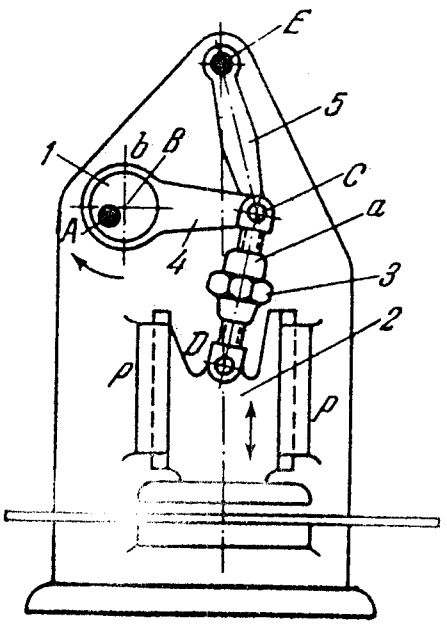
SC HP




Link *3* is connected by turning pair *D* to connecting rod *4* of slider-crank linkage *ABC*. Slider *2* of this linkage is designed as the ram which slides in fixed guides *a-a*. Crank *1* rotates about fixed axis *F* and is connected by turning pair *E* to link *3*. When crank *1* rotates about axis *F*, ram die *2* reciprocates.

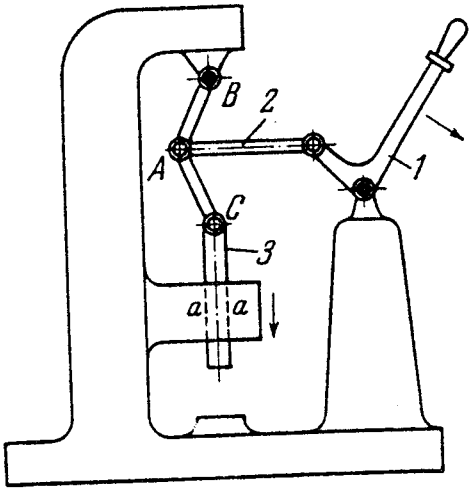
## 1630 SLIDER-CRANK PRESS MECHANISM

SC HP



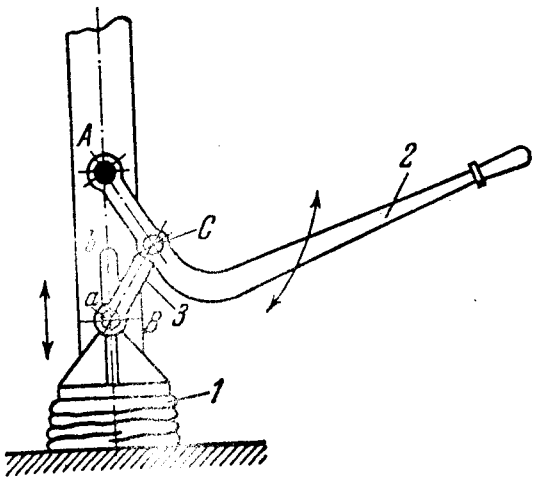

Eccentric *1* rotates about fixed axis *A*. Connecting rod *4* of four-bar linkage *ABCE* has collar *b* encircling eccentric *1*. Link *3* is connected by turning pairs *C* and *D* to rocker arm *5* and slider *2* which moves along fixed guides *p-p*. When eccentric *1* rotates about axis *A*, slider *2* (the press slide), reciprocates. The position of the stroke of slider *2* is adjusted by screw device *a*.

| 1631 | SLIDER-CRANK MECHANISM OF A HAND-OPERATED PRESS (TOGGLE-LEVER PRESS) | SC HP |
|---|---|---|



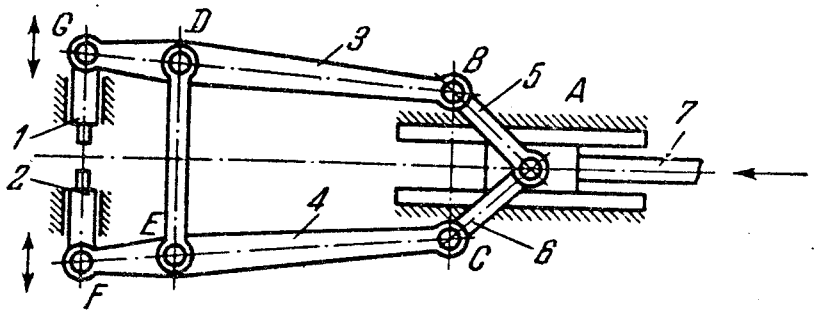

The lengths of the links comply with the condition: $\overline{AB} = \overline{AC}$. Link *3* is of prismatic cross-section and slides in fixed guides *a-a*. When lever *1* is turned, link *3* is advanced to perform the pressworking operation.

| 1632 | THREE-BAR SLIDER-CRANK MECHANISM OF A HAND-OPERATED PRESS (TOGGLE-LEVER PRESS) | SC HP |
|---|---|---|




...oint *B* connecting rod 3 has roller *a* ... s along slot *b* ... whose width equals the diameter of roller *a*. ...Workpiece *1* is pressworked by the effort applied to the handle of lever *2* which is the crank of slider-crank linkage *ACB*.

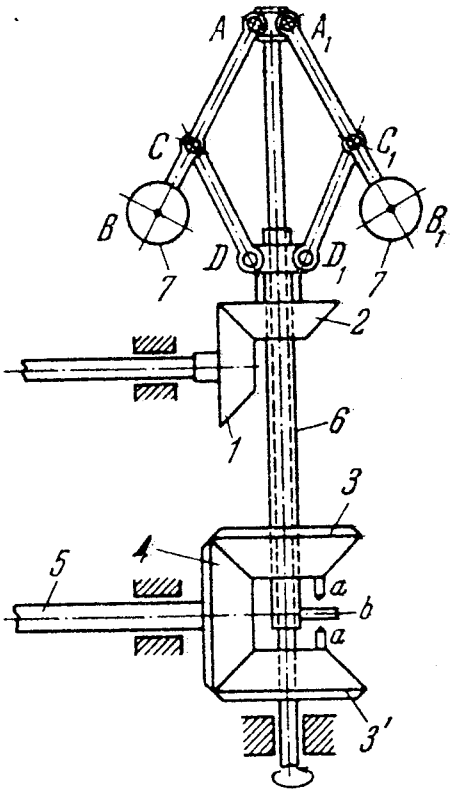
| 1633 | SLIDER-CRANK PRESS MECHANISM | SC HP |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AB} = \overline{AC}$, $\overline{BG} = \overline{CF}$ and $\overline{BD} = \overline{CE}$. When slider *7* moves to the left, links *1* and *2* advance symmetrically toward each other, performing the pressworking operation. Due to the two degrees of freedom, the forces applied to links *3* and *4*, and *5* and *6* are always equalized.

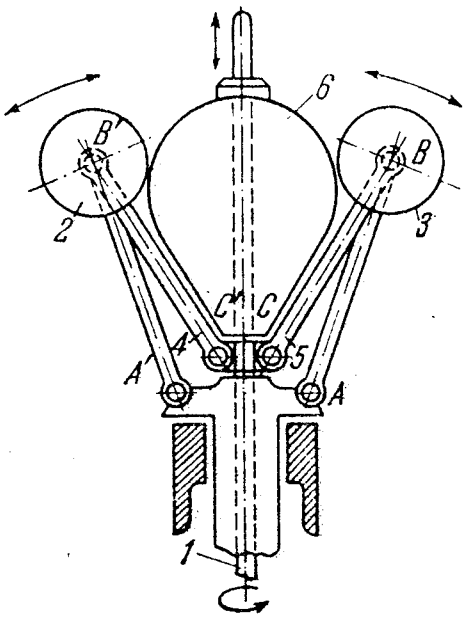
# 12. GOVERNOR MECHANISMS (1634 through 1639)

| 1634 | SLIDER-CRANK MECHANISM OF A CENTRIFUGAL GOVERNOR | SC G |
|---|---|---|



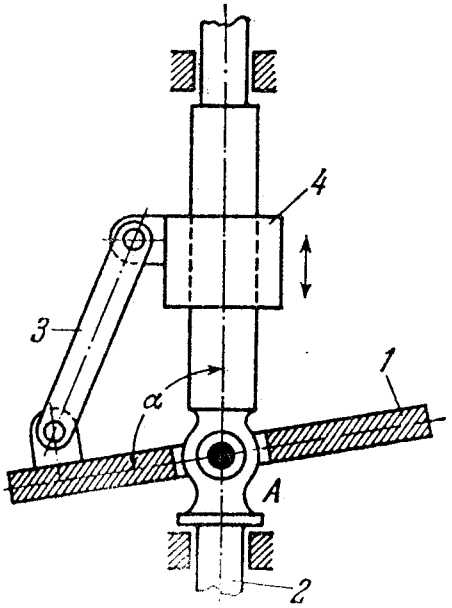

The lengths of the links comply with the conditions: $\overline{AC} = \overline{A_1C_1}$, $\overline{CD} = \overline{C_1D_1}$ and $\overline{CB} = \overline{C_1B_1}$. Weights *7* are of equal weight. The governor is driven by a pair of bevel gears, *1* and *2*. Mounted freely on sleeve *6* are two more bevel gears, *3* and *3'*, which have pins *a*. When the speed of the governor is increased, weights *7* raise sleeve *6* so that pin *b*, secured to sleeve *6*, engages pin *a* of upper bevel gear *3* which meshes with bevel gear *4*, thereby turning shaft *5* to reduce the admission of water (or steam). If the speed is reduced, the sleeve descends, pin *b* engages pin *a* of lower bevel gear *3'* and shaft *5* is turned in the opposite direction to increase the admission of water (or steam).

| 1635 | SLIDER-CRANK MECHANISM OF A CENTRIFUGAL GOVERNOR | SC G |
|---|---|---|



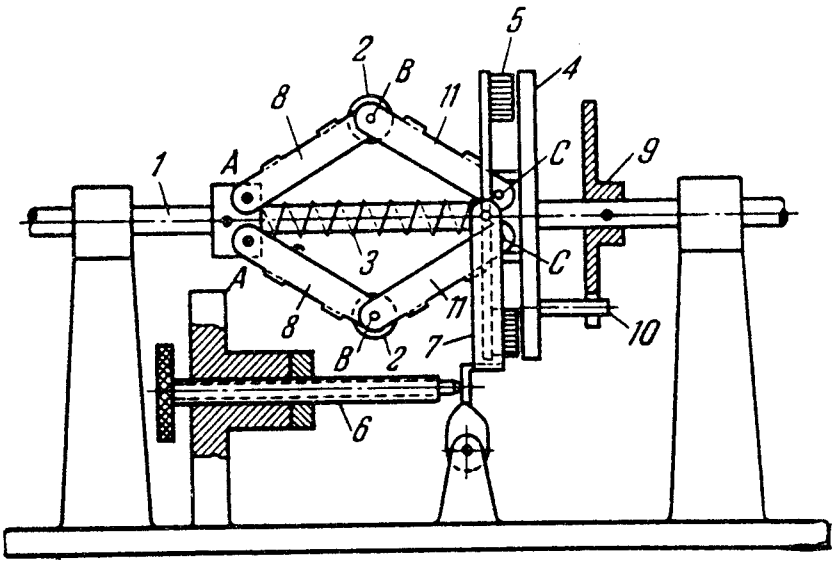

The lengths of the links comply with the conditions: $\overline{AB} = \overline{A'B'}$ and $\overline{BC} = \overline{B'C'}$. Weights *2* and *3* are of equal weight. When the speed of rotation of shaft *1* changes, weights *2* and *3* move either toward or away from each other, moving link *6* along shaft *1* either downward or upward.

| 1636 | SLIDER-CRANK MECHANISM OF A CENTRIFUGAL GOVERNOR | SC G |
|---|---|---|




Link *1* is designed as a round plate turning about axis *A*. The angle $\alpha$ between the plane of plate *1* and the axis of rotation of shaft *2* depends upon the centrifugal force. When angle $\alpha$ is changed, connecting rod *3* slides sleeve *4* along the axis of shaft *2*.

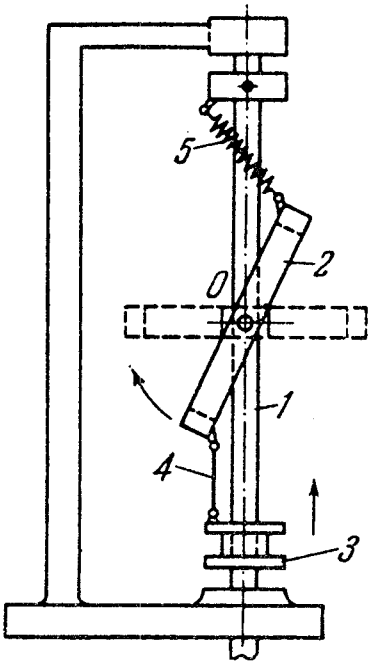
| 1637 | SLIDER-CRANK MECHANISM OF THE GOVERNOR OF AN ELECTRICAL CALCULATING MACHINE | SC G |
|---|---|---|




The lengths of the links comply with the condition: $\overline{AB} = \overline{BC}$. Links *8* turn about axes *A* of shaft *1*. Connecting rods *11* are connected by turning pairs *C* to brake disk *4* which slides along the axis of shaft *1*. When shaft *1* rotates, weights *2* are moved outward by centrifugal force and, overcoming the resistance of spring *3*, force brake disk *4* against a ring with brushes *5*. This ring can be adjusted axially by screw *6* and fork-shaped brushholder *7*. Disk *9* and pin *10* are provided to avoid bending and torsion loads on links *8* on which weights *2* are mounted.

## 1638 SLIDER-CRANK MECHANISM OF A CENTRIFUGAL GOVERNOR

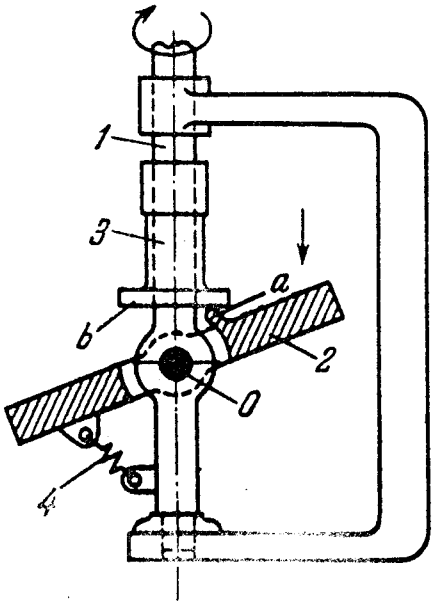
SC G




Link *2* is a disk or a ring with a heavy rim. When the speed of shaft *1* changes, link *2* is turned about axis *O* by centrifugal force, shifting sleeve *3* by means of tie-rod *4* along the axis of shaft *1*. Spring *5* tends to return link *2* to its initial position.

## 1639 THREE-BAR SLIDER-CRANK MECHANISM OF A CENTRIFUGAL SPRING-LOADED GOVERNOR

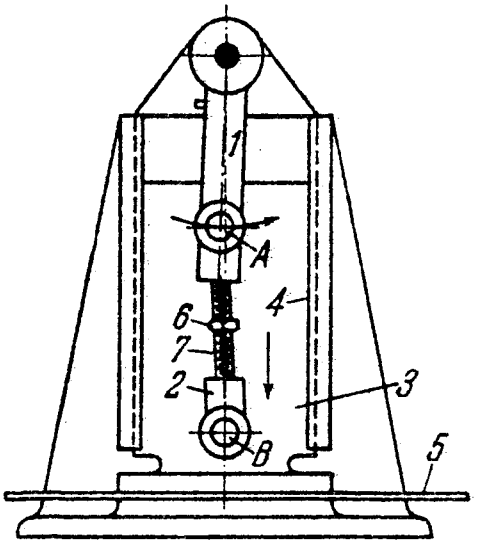
SC G




Link *2*, designed as a heavy disk, has pin *a* on one face. Pin *a* slides along surface *b* of link *3*. When the speed of shaft *1* is changed, link *2* is turned by centrifugal force about axis *O*, shifting link *3* along shaft *1*. Spring *4* tends to return link *2* to its initial position.

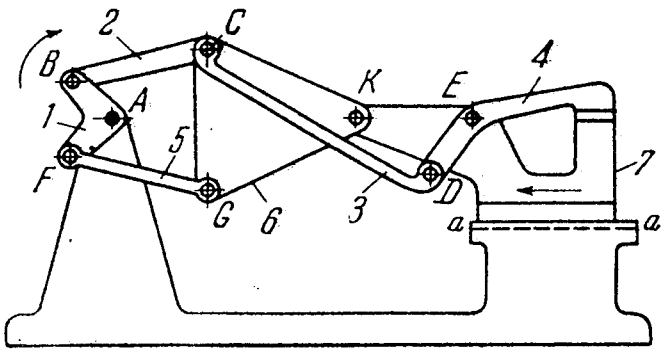
# 13. GRIPPING, CLAMPING AND EXPANDING MECHANISMS (1640 through 1644)

| 1640 | SLIDER-CRANK MECHANISM OF A STRIP-CLAMPING DEVICE | SC GC |
|---|---|---|



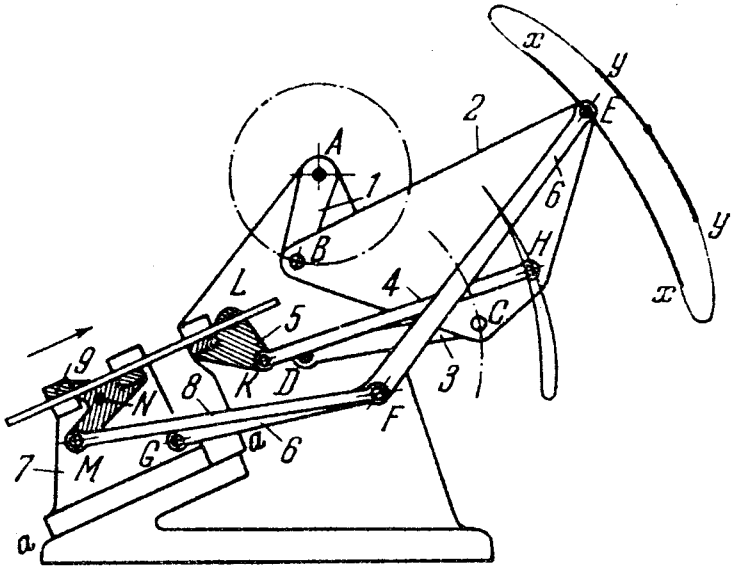

By means of crank *1*, slider *3* moves along guides *4* of the frame and clamps strip *5*. The length of connecting rod *2*, connected by turning pairs *A* and *B* to crank *1* and slider *3*, can be varied by turning head *6* which is rigidly secured to screw *7*. Screw *7* has right-hand thread on one side of head *6* and left-hand thread on the other side.

| 1641 | SLIDER-CRANK GRIPPING AND FEEDING MECHANISM | SC GC |
|---|---|---|



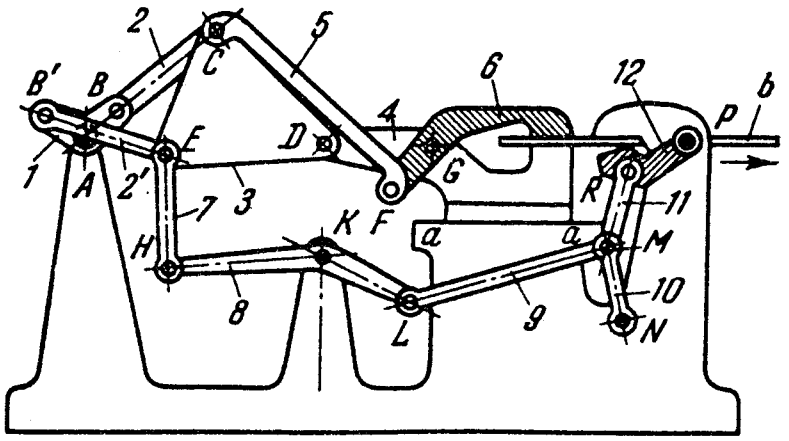

The lengths of the links comply with the conditions: $\overline{AB} = \overline{AF}$, $\overline{BC} = \overline{FG} = \overline{CG}$, $\overline{CK} = \overline{GK} = 3\overline{AB}$, $\overline{KE} = 2.2\overline{AB}$, $\overline{DE} = 1.2\overline{AB}$ and $\overline{CD} = 4.6\overline{AB}$. Slider *7* is reciprocated along fixed guides *a-a* by connecting rod *6* and is actuated from double crank *1* through intermediate links *2* and *5*. By means of intermediate link *3*, the stock is clamped by link *4* which turns about axis *E* of slider *7*.

| 1642 | SLIDER-CRANK GRIPPING, FEEDING AND REGRIPPING MECHANISM | SC GC |
|---|---|---|



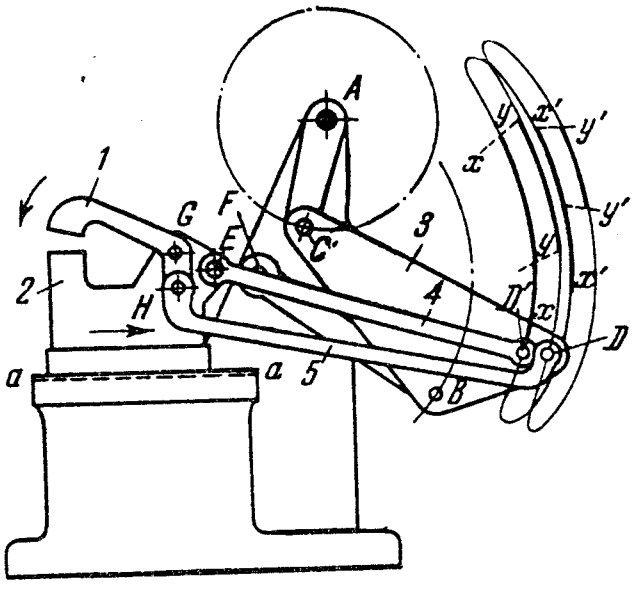

The lengths of the links comply with the conditions: $\overline{BC} = 2.2\overline{AB}$, $\overline{CE} = 2.6\overline{AB}$, $\overline{BE} = 3.6\overline{AB}$, $\overline{EH} = 2.5\overline{AB}$, $\overline{CH} = 0.8\overline{AB}$, $\overline{DC} = 1.9\overline{AB}$, $\overline{AD} = 2\overline{AB}$, $\overline{MF} = 3.4\overline{AB}$, $\overline{EF} = 3.9\overline{AB}$, $\overline{GF} = 2.3\overline{AB}$, $\overline{HK} = 3.1\overline{AB}$ and $\overline{KL} = \overline{MN} = 0.55\overline{AB}$. Slider *7* is reciprocated along fixed guides *a-a* by link *6* which is connected by turning pair *E* to connecting rod *2*. Slider *7* has dwells during the periods of time while point *E* travels along portions *x-x* and *y-y* of its path since these portions approximate circular arcs described from the corresponding positions of point *G*. Link *8*, actuating link *9*, periodically grips and releases the stock. The stock is regripped when it is released by link *9* by means of link *5* which is actuated by link *4*. Link *4* is connected by turning pair *H* to connecting rod *2*.

| 1643 | SLIDER-CRANK GRIPPING, FEEDING AND REGRIPPING MECHANISM | SC GC |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{AB} = \overline{AB'}$, $\overline{BC} = \overline{B'E} = \overline{CE} = 2.8\overline{AB}$, $\overline{CD} = \overline{ED} = 3.2\overline{AB}$, $\overline{EH} = 2.8\overline{AB}$, $\overline{HK} = 3.36\overline{AB}$, $\overline{KL} = 2\overline{AB}$, $\overline{LM} = 4.6\overline{AB}$, $\overline{MN} = \overline{MR} = 1.6\overline{AB}$, $\overline{RP} = 1.2\overline{AB}$, $\overline{FG} = 1.4\overline{AB}$, $\overline{CF} = 5\overline{AB}$, $\overline{AK} = 5.8\overline{AB}$, $\overline{AN} = 12.3\overline{AB}$, $\overline{KN} = 6.6\overline{AB}$, $\overline{PN} = 4\overline{AB}$ and $\overline{KP} = 8\overline{AB}$. By means of intermediate links *2* and *3*, double-crank link *1* reciprocates slider *4* along fixed guides *a-a*. Link *5*, actuating link *6*, periodically grips and releases stock *b*, feeding it in the required direction. The stock is regripped by link *12* (when it is released by link *6*) which is connected to crank $AB'$ of link *1* by a kinematic chain consisting of links *2'*, *7*, *8*, *9*, *10* and *11*. The mechanism is set up and adjusted by varying the angle between cranks $AB$ and $AB'$.

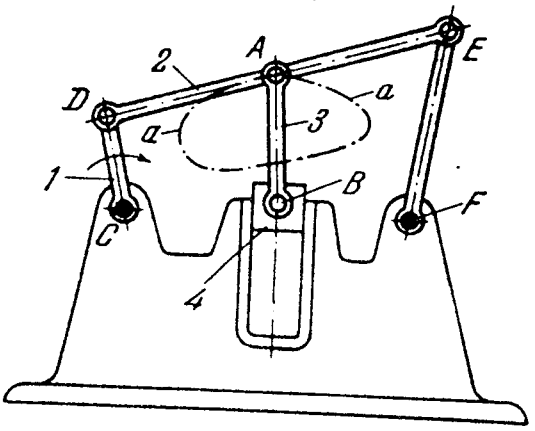
| 1644 | SLIDER-CRANK GRIPPING AND FEEDING MECHANISM | SC GC |
|---|---|---|




The lengths of the links comply with the conditions: $\overline{BC} = 2\overline{AC}$, $\overline{BD'} = 0.9\overline{AC}$, $\overline{BD} = 1.1\overline{AC}$, $\overline{CD} = 2.55\overline{AC}$, $\overline{CD'} = 2.32\overline{AC}$, $\overline{BF} = 2\overline{AC}$, $\overline{AF} = 1.6\overline{AC}$, $\overline{ED'} = 2.8\overline{AC}$, $\overline{HD} = 3.6\overline{AC}$ and $\overline{HG} = 0.35\overline{AC}$. Connecting rod *3* actuates links *4* and *5*. Link *4* is connected by turning pair *E* to slider *2* which reciprocates along fixed guides *a-a*. Link *5* is connected by turning pair *H* to link *1* which turns about axis *G* of slider *2*. Slider *2* has dwells during the periods of time while point *D'* travels along portions *x-x* and *x'-x'* of its path since these portions approximate circular arcs described from the corresponding positions of point *E*. The stock is gripped and held by link *1*, and it is released and link *1* is kept open, during the periods of time while point *D* travels along portions *y-y* and along *y'-y'* of its path since these portions approximate circular arcs described from the corresponding positions of point *H*.

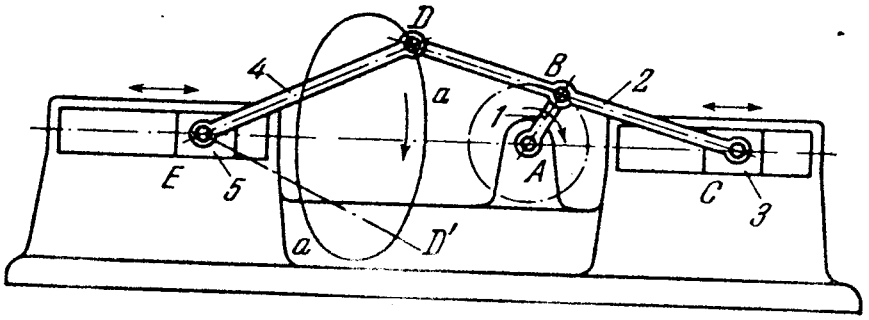
# 14. DWELL MECHANISMS (1645 through 1648)

| 1645 | SLIDER-CONNECTING ROD DWELL MECHANISM | SC D |
|---|---|---|

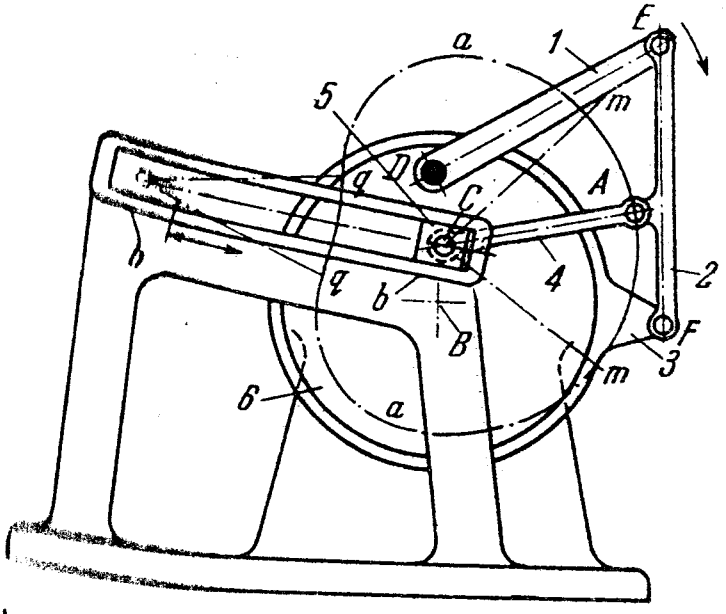



Connecting rod *3* is connected by turning pairs *A* and *B* to link *2* of four-bar linkage *CDEF* and to slider *4*. When crank *1* rotates about fixed axis *C*, slider *4* is almost stationary at the portion of the path *a-a* of point *A* that approximates a circular arc described from point *B* as its centre. Thus, slider *4* practically has a dwell

| 1646 | SLIDER-CRANK MECHANISM WITH ATTACHED CONNECTING ROD AND SLIDER HAVING DWELLS | SC D |
|---|---|---|

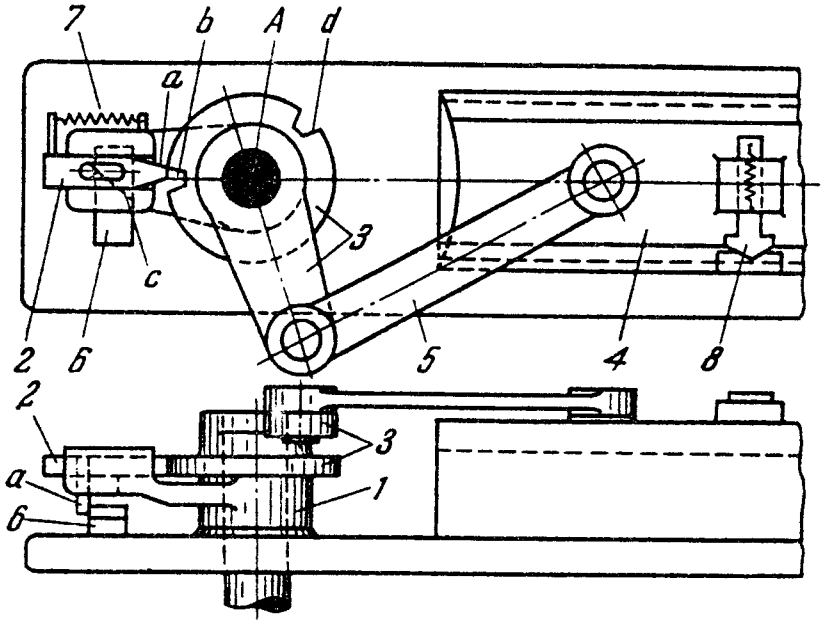



The lengths of the links comply with the conditions: $\overline{BC} = 3\overline{AB}$, $\overline{BD} = 2.5\overline{AB}$ and $\overline{ED} = 3.5\overline{AB}$. Portion $DD'$ of path *a-a* of point *D* approximates a circular arc described with radius $\overline{ED}$ from point *E*. Slider *5* is practically stationary when point *D* travels along this portion of its




Connecting rod *4* is connected by turning pair *C* to slider *5* which moves along fixed guides *b-b*. Connecting rod *4* is connected by turning pair *A* to connecting rod *2* of four-bar drag-link linkage *DEFA*. Crank *3* is designed as a collar encircling fixed round disk *6* with its centre at point *B*. Point *A* of connecting rod *2* describing connecting-rod curve *a-a* whose portions *q-q* and *m-m*, shown by continuous lines, approximate circular arcs with centres at positions of point *C* and of a radius equal to length *CA* of connecting rod *4*. While point *A* travels along these portions of its path, slider *5* is practically stationary, i.e. it has two dwells in its extreme positions.

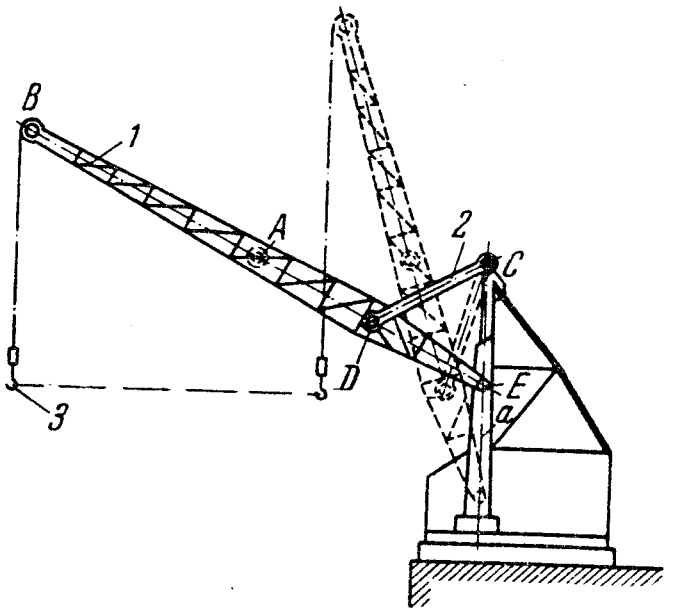
| 1648 | SLIDER-CRANK DWELL MECHANISM | SC D |
|---|---|---|




Slider *2* moves with respect to lever *1* which is rigidly mounted on shaft *A*. Slider *2* engages grooves of crank *3*. When crank *3* rotates, slider *4* is reciprocated by connecting rod *5*. When lever *1* rotates, pin *a* of slider *2* runs up against bevel *c* of fixed cam *6* and travels along the cam. At this, slider *2*, overcoming the resistance of spring *7*, is shifted to the left, disengaging groove *b* of crank *3*. When this occurs, slider *4* stops in a definite position indexed by spring-loaded stop *8*. Upon further rotation of lever *1*, slider *2* engages groove *d* of crank *3* and slider *4* starts moving again. Thus, slider *4* reciprocates with dwells.

# 15. MECHANISMS OF MATERIALS HANDLING EQUIPMENT (1649)

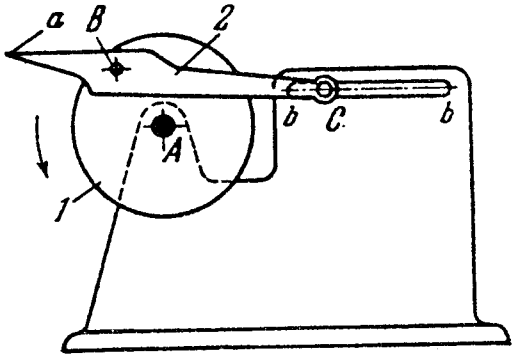
| 1649 | SLIDER-CRANK MECHANISM OF A CRANE | SC MH |
|---|---|---|




The lengths of the links comply with the condition: $\overline{CD} = \overline{DE} = \overline{AD}$. Link *2* turns about fixed axis *C*. The end *E* of truss-type boom *1* slides along fixed guide *a*. When point *E* of boom *1* slides along guide *a*, point *A* of the boom travels in a straight line in the direction *AC*. Point *B* describes an arc of an ellipse. If the hoisting rope is let out while the reach of the crane is changed, hoisting hook *3* will travel horizontally.

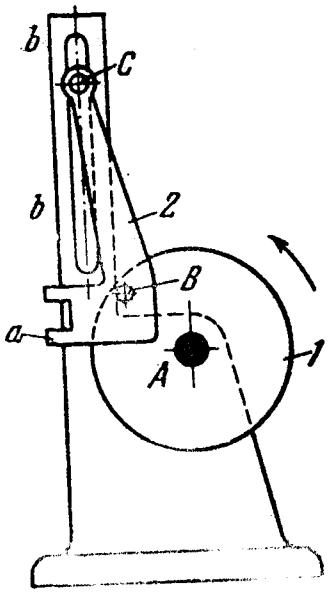
# 16. OPERATING CLAW MECHANISMS OF MOTION PICTURE CAMERAS (1650 through 1657)

| | | |
|---|---|---|
| 1650 | THREE-BAR SLIDER-CRANK OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA | SC OC |



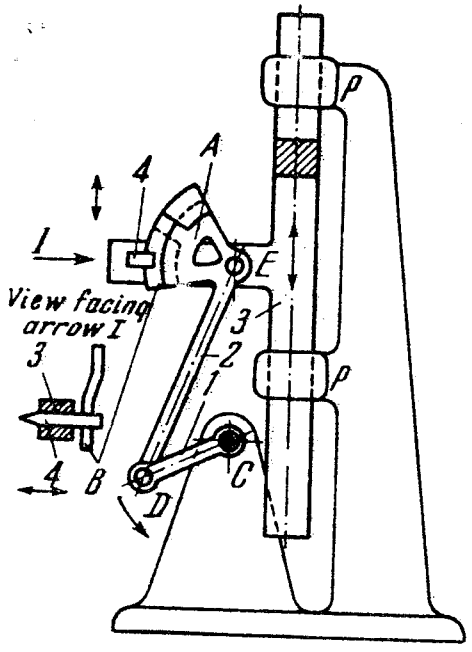

When crank *1* of three-bar slider-crank linkage *ABC* rotates about fixed axis *A*, the tip of claw *a* of link *2* describes a connecting-rod curve. Pin *C* of link *2* slides along fixed slot *b-b*. At one portion of the connecting-rod curve, claw *a* is inserted into a perforation of the film which it advances. At another portion of the curve, claw *a* is withdrawn from the perforation.

| | | |
|---|---|---|
| 1651 | THREE-BAR SLIDER-CRANK OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA | SC OC |



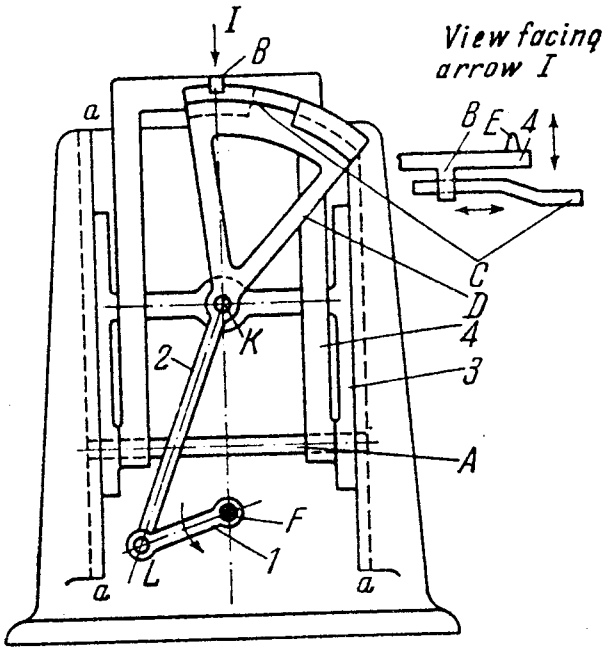

When crank *1* of three-bar slider-crank linkage *ABC* rotates about fixed axis *A*, the tip of claw *a* of link *2* describes a connecting-rod curve. Pin *C* of link *2* slides along fixed slot *b-b*. At one portion of the connecting-rod curve, claw *a* is inserted into a perforation of the film which it advances. At another portion of the curve, claw *a* is withdrawn from the perforation.

| 1652 | SPATIAL SLIDER-CRANK OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA | SC OC |
|---|---|---|



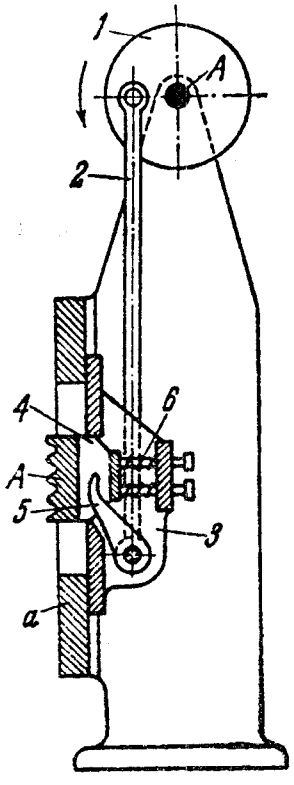

Crank *1* rotates about fixed axis *C*. Connecting rod *2* is connected by turning pairs *D* and *E* to crank *1* and to slider *3* which moves in fixed guides *p-p*. Link *2* has sector *A* at one end. The edge *B* of sector *A* is bent into the shape shown by the view facing arrow *I*. Pin *4* slides in a rectangular hole of slider *3* and has a slot which engages edge *B*. When crank *1* rotates about axis *C*, slider *3* reciprocates. Pin *4* travels together with slider *3*. In the down-stroke of slider *3*, sector *A* advances pin *4* to insert its claw into a perforation of the film which it moves downward. In the up-stroke of slider *3*, sector *A* withdraws pin *4* from the perforation.

| 1653 | SPATIAL SLIDER-CRANK OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA | SC OC |
|---|---|---|



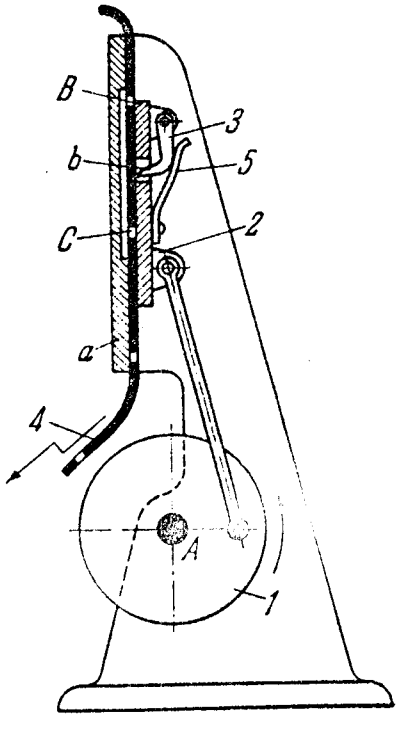

Crank *1* rotates about fixed axis *F*. Connecting rod *2* is connected by turning pairs *L* and *K* to crank *1* and to slider *3* which moves along fixed guides *a-a*. Link *2* has sector *D* at one end. Frame *4* turns about axis *A* of slider *3* and has catch *B* which slides along edge *C* of sector *D*. Edge *C* is bent into the shape shown by the view facing arrow *I*. When crank *1* rotates about axis *F*, slider *3* reciprocates. Frame *4* turns about axis *A* and reciprocates with slider *3*. Catch *B* of frame *4* engages the stepped edge *C* of sector *D*. In the down-stroke of slider *3*, sector *D* advances claw *E*, mounted on frame *4* to insert it into a perforation of the film which it moves downward. In the up-stroke of slider *3*, sector *D* withdraws claw *E* from the perforation.

| 1654 | OFFSET SLIDER-CRANK OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA | SC OC |
|---|---|---|



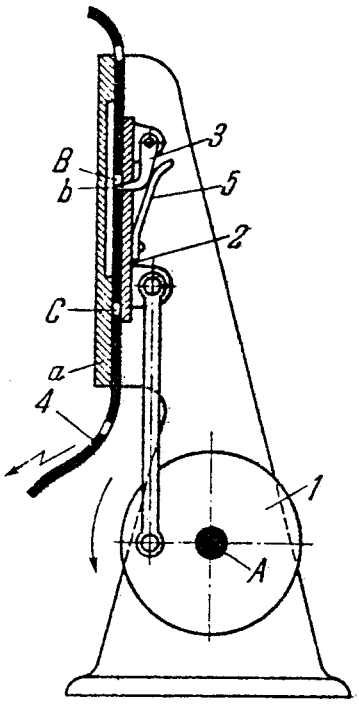

Crank *1* rotates about fixed axis *A*. Slider *3* moves along fixed guide *a*. When crank *1* rotates about axis *A*, slider *3* reciprocates. Link *4* with claws *A* reciprocates together with slider *3*. Link *5*, rigidly secured to connecting rod *2*, withdraws claws *A* of link *4* from the perforations of the film, and springs *6* insert the claws into perforations of the film.

| 1655 | ALIGNED SLIDER-CRANK OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA | SC OC |
|---|---|---|



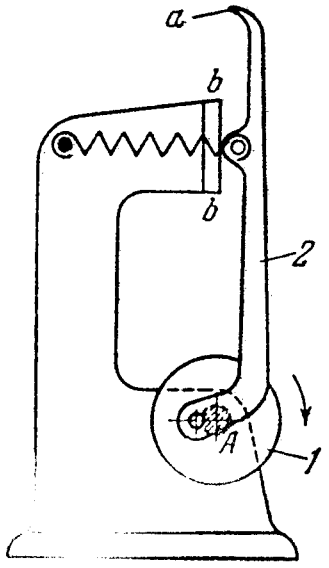

Crank *1* rotates about fixed axis *A*. Slider *2* moves along fixed guide *a*. When crank *1* rotates about axis *A*, slider *2*, carrying pawl *3* and flat spring *5*, reciprocates. In the upstroke of slider *2*, pawl *3* comes out of perforation *C* of film *4* and slides along the film with its rounded tip *b*. In the downstroke of slider *2*, spring *5* inserts pawl *3* into perforation *B* of film *4* and the pawl advances the film downward.

| 1656 | OFFSET SLIDER-CRANK OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA | SC OC |
|---|---|---|




When crank *1* rotates about fixed axis *A*, slider *2*, carrying pawl *3* and flat spring *5*, reciprocates along fixed guide *a*. In the up-stroke of slider *2*, pawl *3* comes out of perforation *C* of film 4 and slides along the film with its rounded tip *b*. In the down-stroke of slider *2*, spring *5* inserts pawl *3* into perforation *B* of film *4* and the pawl advances the film downward.

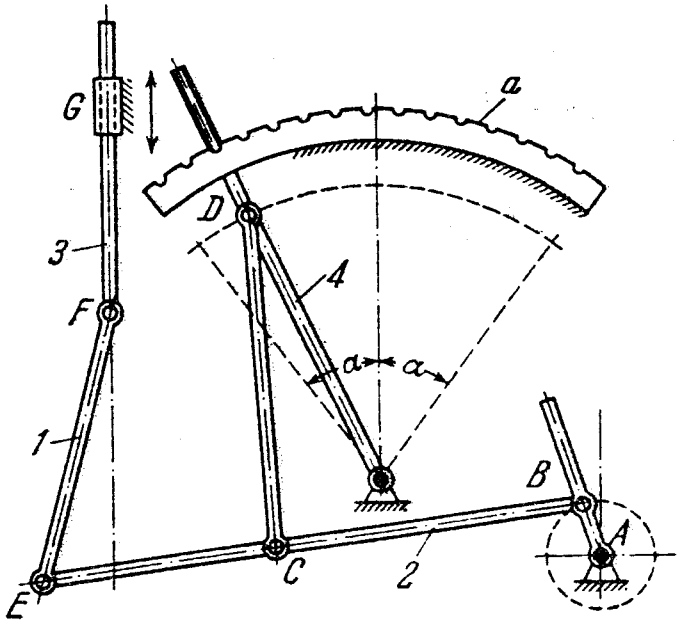
| 1657 | SLIDER-CRANK OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA | SC OC |
|---|---|---|




When crank *1* rotates about fixed axis *A*, connecting rod *2* slides along flat surface *b-b* of the upright and the tip of claw *a* describes a complex connecting-rod curve. At one portion of this curve, claw *a* is inserted into a perforation of the film which it advances. At another portion of the curve, claw *a* is withdrawn from the perforation.

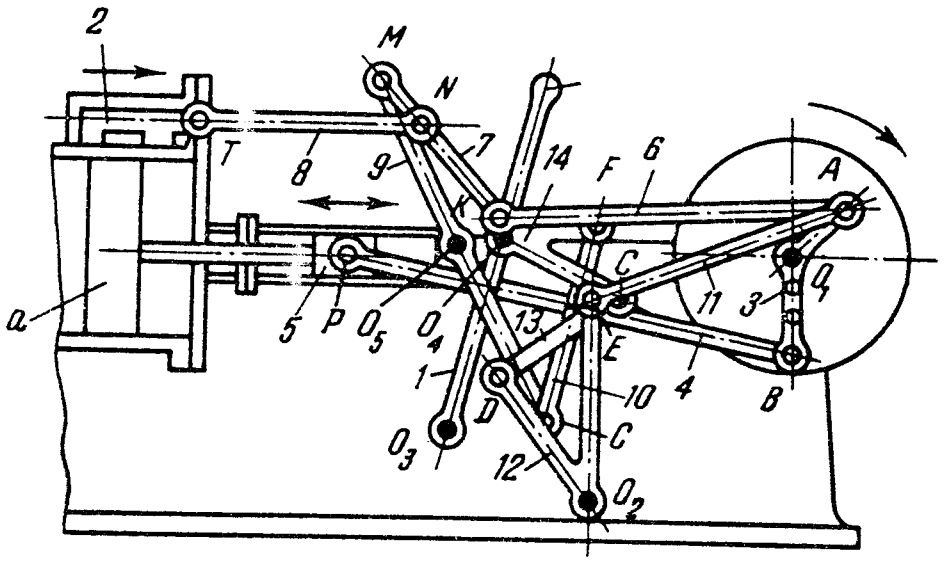
# 17. VALVE GEAR MECHANISMS
## (1658 and 1659)

| 1658 | SLIDER-CRANK VALVE GEAR MECHANISM | SC VG |
|---|---|---|




Connecting rod *1* is connected by turning pairs *E* and *F* to connecting rod *2* of four-bar linkage *ABCD* and to rod *3* of valve *G*. The stroke of the valve is varied by setting lever *4* to the proper position within the limits of an angle equal to $2\alpha$ and fixing it by a tooth entering one of the slots of toothed quadrant *a*.

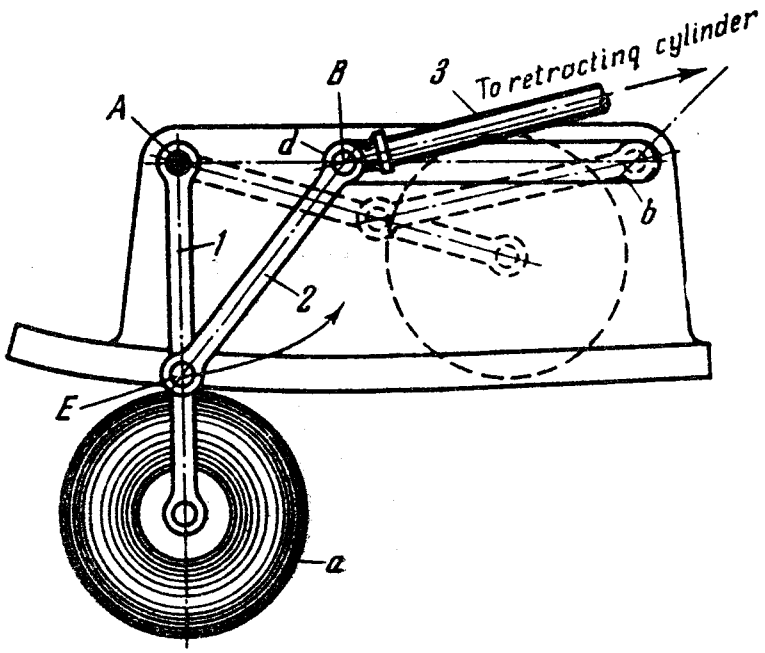
| 1659 | SLIDER-CRANK MECHANISM OF THE CHEBYSHEV STEAM ENGINE | SC VG |
|---|---|---|




Double crank *3* rotates about fixed axis $O_1$. Connecting rod *4* is connected by turning pairs *B* and *P* to crank *3* and slider *5* which is driven by piston *a* of the steam engine. Reciprocation is transmitted to slide-valve *2* through a complex system of levers. Link *7* is connected by turning pair *N* to connecting rod *8* of slide valve *2*. Link *7* is actuated from one end by crank *3* through connecting rod *6*, and from the other end by the same crank but through links *11*, *12*, *13*, *14*, *10* and *9*. Links *12* and *9* turn about fixed axes $O_2$ and $O_5$, and link *14* about fixed axis $O_4$ of lever *1* which turns about fixed axis $O_3$. Lever *1* can be set at various positions, thereby changing the position of fixed axis $O_4$ of revolution of lever *14*. This also changes the path of point *N* of link *7* and, consequently, the motion of slide valve *2*. Lever *1* is shown in its extreme position for which the stroke of slide valve *2* is the maximum.

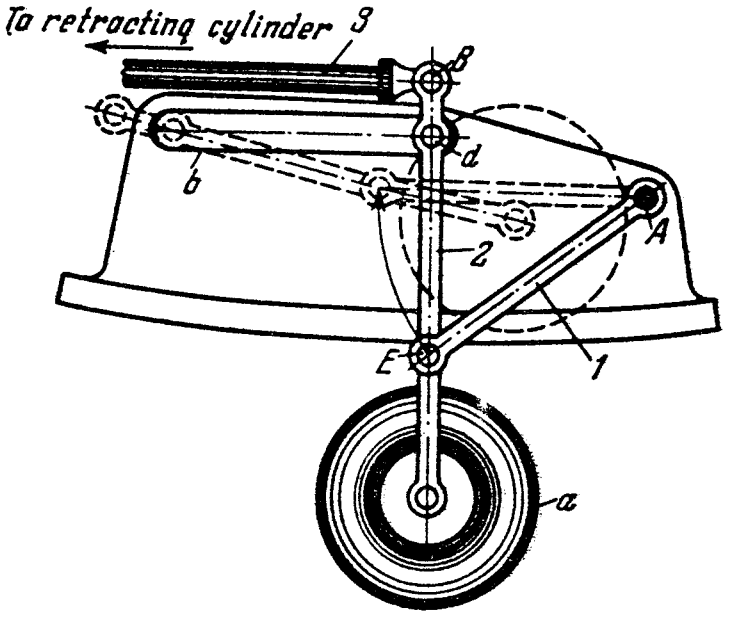
# 18. AIRCRAFT LANDING GEAR MECHANISMS
## (1660 through 1664)

| 1660 | SLIDER-CRANK RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | SC AL |
|---|---|---|




Link *1* with wheel *a* turns about fixed axis *A* of the aircraft frame member. Connecting rod *2* is connected by turning pair *E* to link *1* and its end *d* slides along fixed guide *b*. Link *2* is connected by turning pair *B* to piston rod *3* of the retracting cylinder. When piston rod *3* moves into the retracting cylinder, link *1* is turned counterclockwise, and the landing gear is retracted as shown by the dash lines.

| 1661 | SLIDER-CRANK RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | SC AL |
|---|---|---|

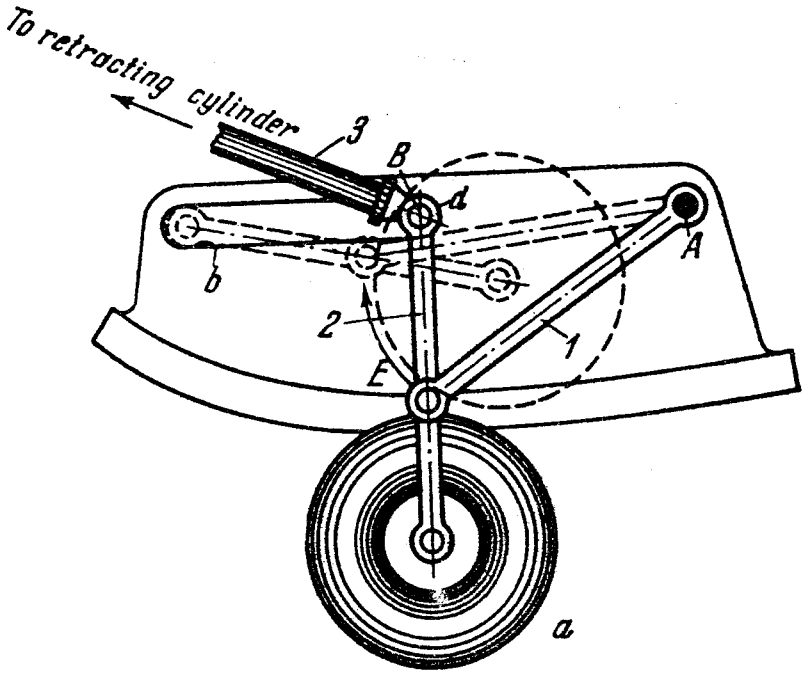



Link *1* turns about fixed axis *A* of the aircraft frame member. Connecting rod *2* with wheel *a* is connected by turning pair *E* to link *1* and it has roller *d* which slides along fixed guide *b*. Link *2* is connected by turning pair *B* to piston rod *3* of the retracting cylinder. When piston rod *3* moves into the retracting cylinder, link *1* is turned clockwise, and the landing gear is retracted as shown by the dash lines.

| | |
|---|---|
| r | SC<br>AL |

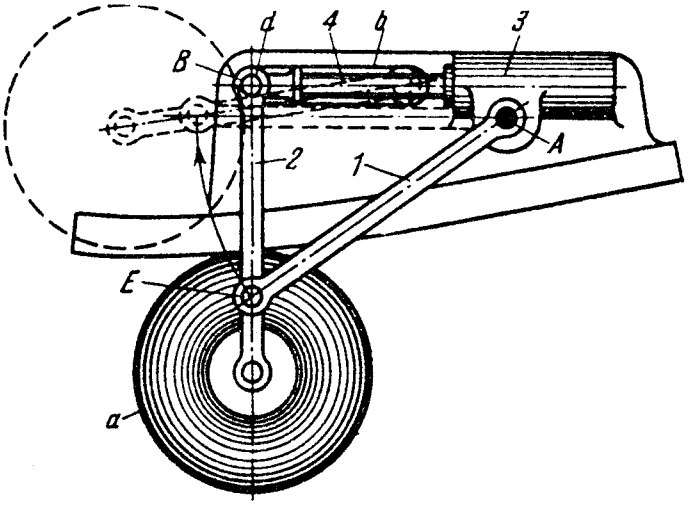
iember.
pair *E*
uide *b*.
of the
racting
gear is

| | | |
|---|---|---|
| 1662 | SLIDER-CRANK RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | SC<br>AL |



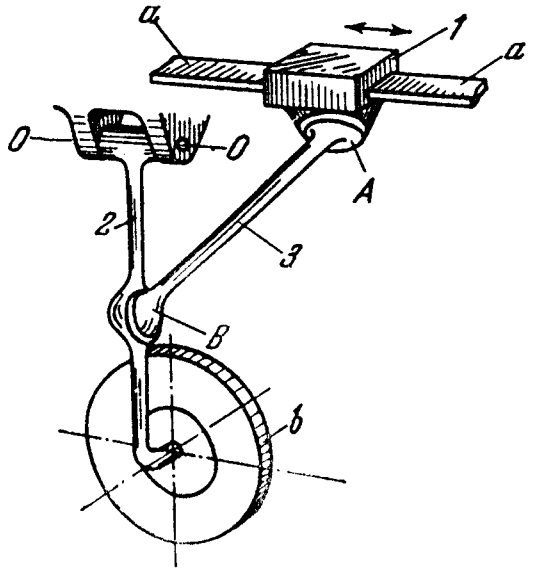

Link *1* turns about fixed axis *A* of the aircraft frame member. Connecting rod *2* with wheel *a* is connected by turning pair *E* to link *1* and its end *d* slides along fixed guide *b*. Link *2* is connected by turning pair *B* to piston rod *3* of the retracting cylinder. When piston rod *3* moves into the retracting cylinder, link *1* is turned clockwise, and the landing gear is retracted as shown by the dash lines.

| 1663 | SLIDER-CRANK RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | SC AL |
|---|---|---|




Link *1* turns about fixed axis *A* of the aircraft frame member. Connecting rod *2* with wheel *a* is connected by turning pair *E* to link *1* and its end *d* slides along fixed guide *b*. Link *2* is connected by turning pair *B* to piston rod *4* of retracting cylinder *3*. When piston rod *4* moves into retracting cylinder *3*, link *1* is turned clockwise, and the landing gear is retracted as shown by the dash lines.

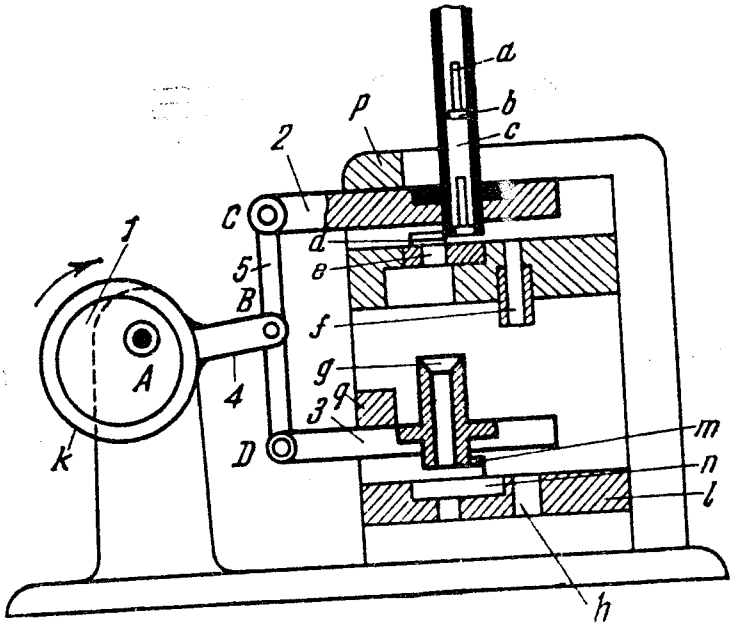
| 1664 | SPATIAL SLIDER-CRANK RETRACTABLE AIRCRAFT LANDING GEAR MECHANISM | SC AL |
|---|---|---|




Link *2* with wheel *b* turns about fixed axis *O-O* of the aircraft frame member. Link *1* slides along fixed guides *a-a*. Link *3* is connected by spherical pairs *A* and *B* to slider *1* and to link *2*. When slider *1* moves along guides *a-a*, link *2* turns about axis *O-O*, retracting the landing gear with wheel *b*.

# 19. SORTING AND FEEDING MECHANISMS
## (1665 through 1669)

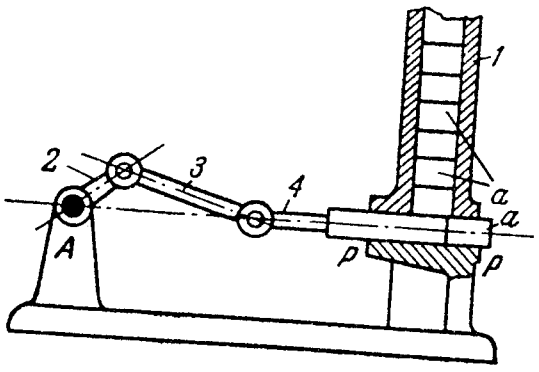
| 1665 | SLIDER-CRANK SORTING MECHANISM | SC SF |
|---|---|---|




Round eccentric *1* rotates about fixed axis *A*. Link *4* has collar *k* encircling the eccentric and is connected by turning pair *B* to cross-piece *5* which, in turn, is connected by turning pairs *C* and *D* to sliders *2* and *3*. Sliders *2* and *3* reciprocate along fixed guides *p* and *q*. The mechanism checks the height of head *b* at the lower end of workpiece *a*. The workpieces are delivered to the mechanism through tube *c* and they drop, head downward, on a fixed plate. Tube *c* is mounted in slider *2* and reciprocates with it when eccentric *1* rotates about axis *A*. Slider *2* advances head *b* of the bottom workpiece into gauge *d*. Workpieces whose head *b* passes through gauge *d* drop through hole *e* and are diverted to one side. Workpieces with a head *b* too high to pass through gauge *d* drop through hole *f* on the return stroke of slider *2*. From hole *f* the workpieces drop into tube *g*, mounted on lower slider *3*, and are advanced to gauge *m*. Workpieces passing through gauge *m* drop through hole *n* of member *l* of the base. The rest of the workpieces drop through hole *h*.

## 1666 SLIDER-CRANK FEEDING MECHANISM

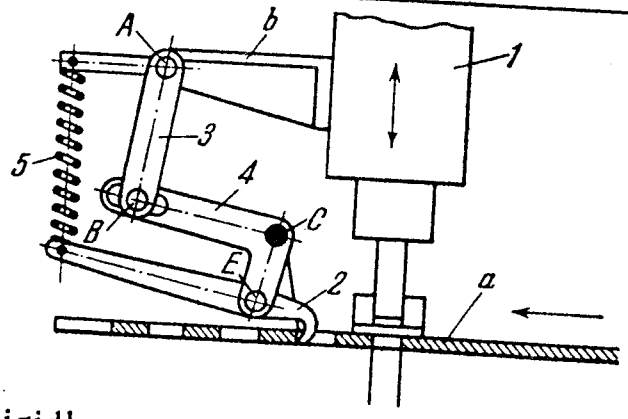
SC
SF




Workpieces *a* drop from magazine *1* onto flat surface *p-p*. A mechanism which is not shown periodically rotates crank *2* through one complete revolution, beginning from its extreme left-hand position. Rotating about fixed axis *A*, crank *2*, by means of connecting rod *3*, reciprocates pusher *4* which ejects bottom workpiece *a* into a chute which is not shown. When crank *2* returns to its extreme left-hand position the next workpiece *a* drops onto flat surface *p-p*.

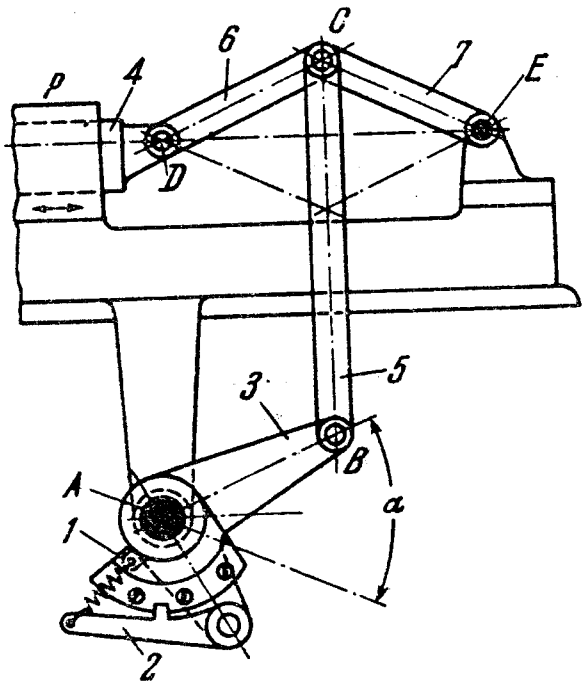
## 1667 SLIDER-CRANK FEEDING MECHANISM

SC
SF



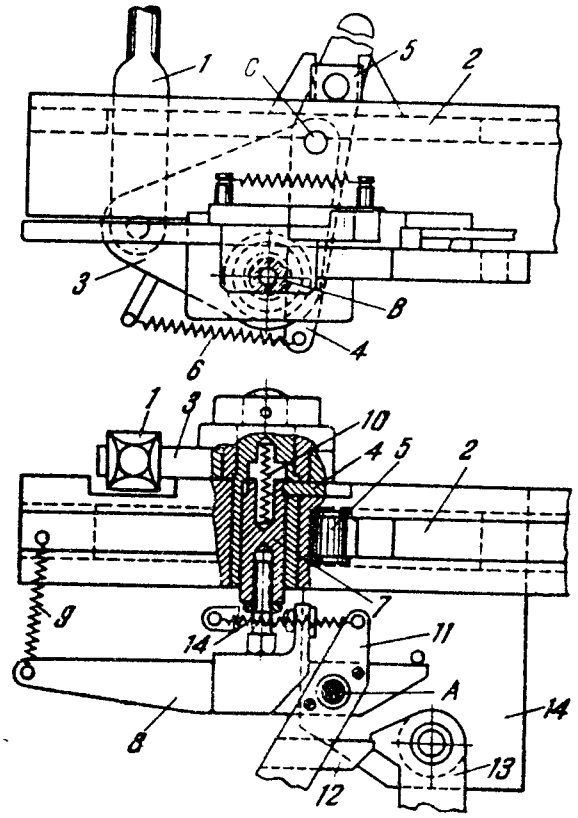

Bracket *b* is rigidly mounted on slide *1* of a press and reciprocates with the slide along vertical guides which are not shown. Link *3* is connected by turning pairs *A* and *B* to links *1* and *4*. Link *4* turns about fixed axis *C* and is connected by turning pair *E* to hook *2*. In the down-stroke of slide *1*, hook *2* has its idle stroke moving along the strip being blanked. [illegible] up-stroke of [illegible], hook *2* engages a hole in strip *a* and moves it to the [illegible] hook stroke and strip feed can be regulated by adjusting and clamping the lower end of tie-rod *3* along the slot of link *4*, and by changing the stroke of the press slide. Spring *5* holds hook *2* against strip *a*.

| 1668 | SLIDER-ROCKER ARM FEEDING MECHANISM WITH A SAFETY DEVICE | SC SF |
|---|---|---|




The lengths of the links comply with the condition: $\overline{CD} = \overline{CE}$. The oscillating motion of shaft *A*, rigidly secured to sector *1*, is transmitted by pawl *2* to bent lever *3*, mounted freely on shaft *A*. Bent lever *3* is oscillated through angle $\alpha$ and imparts reciprocating motion to slider *4* through links *5*, *6* and *7*. Link *7* turns about fixed axis *E*, and slider *4* moves in fixed guide *p*. If slider *4* is jammed, no motion is transmitted to bent lever *3* because the additional force disengages pawl *2* from sector *1*, and shaft *A* oscillates with idle strokes.

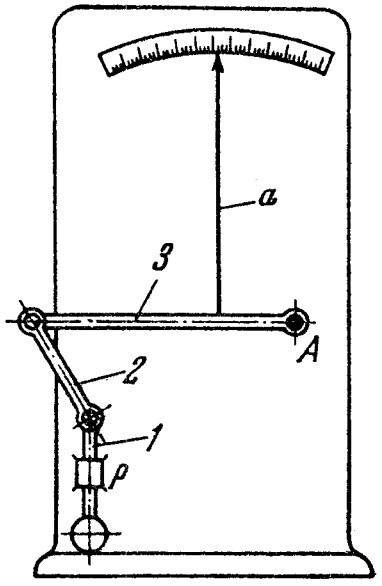
| 1669 | SLIDER-CRANK AUTOMATIC FEED DISENGAGING MECHANISM | SC SF |
|---|---|---|




When link *1* reciprocates, its motion is transmitted through levers *3* and *4*, and link *5* to slider *2* which feeds the workpieces into the press. Lever *3* turns about fixed axis *B* and is connected by turning pair *C* to lever *4* which enters a slot of plunger *7* and is subject to the force of spring *6*. When slider *2* is subject to an overload, occurring when the workpieces being fed jam, the slider stops and lever *4*, overcoming the resistance of spring *6*, comes out of the slot of plunger *7*. This enables lever *8* to turn about axis *A* due to the action of spring *9*. At this, plunger *7* moves upward, compressing spring *10*. Turning together with lever *8* about axis *A* and tensioning spring *14* is lever *11* whose dog *12* disengages link *13*. Link *13* is turned by a spring which is not shown, disengaging the clutch of the press. When the obstruction to workpiece feed has been eliminated, dog *12* is brought into engagement again with link *13*. Compressed spring *10* shifts plunger *7* to its lower position in which it prevents lever *8* from t[illegible] lever *4* is pulled by spring *6* back in[illegible] ment with plunger *7*, and reciprocating motion is again transmitted to slider *2* which again feeds workpieces into the press.

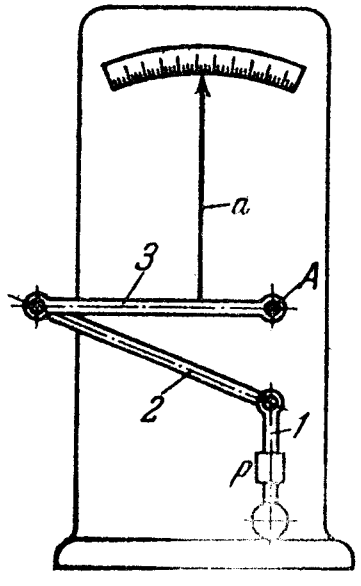
# 20. MECHANISMS OF MEASURING AND TESTING DEVICES (1670 and 1671)

| 1670 | SLIDER-ROCKER ARM MECHANICAL COMPARATOR MECHANISM | SC M |
|---|---|---|




Link *3* with hand *a* turns about fixed axis *A*. Measuring spindle *1* slides in fixed guide *p*. The displacement of measuring spindle *1* is transmitted through links *2* and *3* to hand *a*.

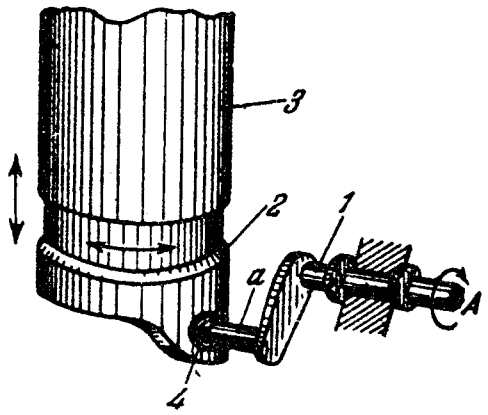
| 1671 | SLIDER-ROCKER ARM MECHANICAL COMPARATOR MECHANISM | SC M |
|---|---|---|




Link *3* with hand *a* turns about fixed axis *A*. Measuring spindle *1* slides in fixed guide *p*. The displacement of measuring spindle *1* is transmitted through links *2* and *3* to hand *a*.

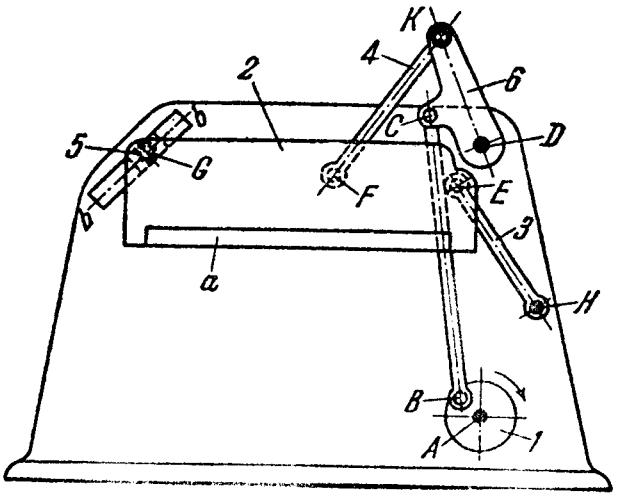
# 21. MECHANISMS OF OTHER FUNCTIONAL DEVICES (1672 through 1683)

| 1672 | SPATIAL SLIDER-CRANK SLEEVE-VALVE CONTROL MECHANISM OF AN ENGINE | SC FD |
|---|---|---|




Crank *1* rotates about fixed axis *A* and has pin *a* which slides and turns with respect to link *4* when the crank rotates. Link *4* is connected by a spherical pair to sleeve *2*. Sleeve *2* is a thin-walled hollow cylinder that slides along the axis of fixed cylinder *3* and simultaneously turns through a definite angle.

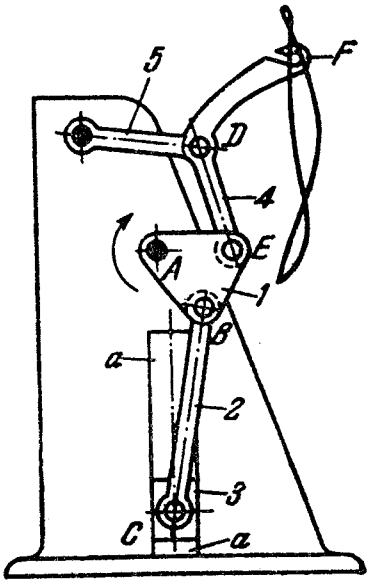
| 1673 | SLIDER-CRANK BLADE MECHANISM OF A TRIMMING MACHINE | SC FD |
|---|---|---|




Holder *2* of blade *a* is connected by turning pairs *E*, *F* and *G* to links *3* and *4* and slider *5*. Link *3* turns about fixed axis *H*. Slider *5* moves along fixed guides *b-b*. Link *4* is connected by turning pair *K* to rocker arm *6* of four-bar linkage *ABCD*. When crank *1* rotates about fixed axis *A*, holder *2* with blade *a* has a complex motion which accomplishes the cutting operation.

## 1674 SLIDER-CRANK THREAD AND NEEDLE GUIDING MECHANISM OF A SEWING MACHINE

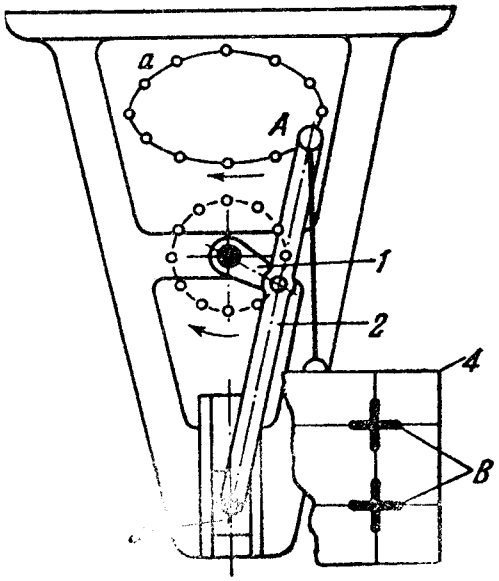
SC
FD




Slider *3* of slider-crank linkage *ABC* reciprocates along fixed guides *a-a*. Crank *1* rotates about fixed axis *A* and is connected by turning pair *E* to link *4* which, in turn, is connected by turning pair *D* to link *5*. When crank *1* rotates about axis *A*, slider *3*, to which the needle is attached, reciprocates. At this, point *F* of connecting rod *4* describes the curve shown in the drawing. This curve is used for threading.

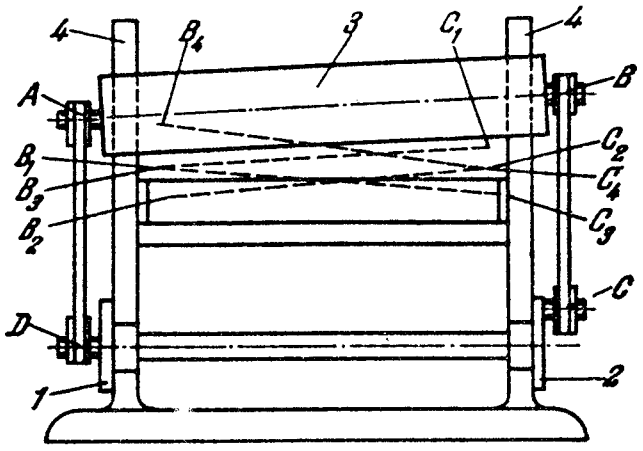
## 1675 SLIDER-CRANK LAMP-BANK MECHANISM OF A REPRODUCING DEVICE

SC
FD



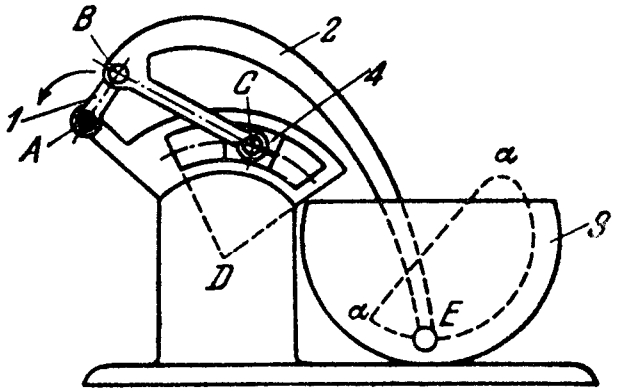

When crank *1* rotates about a fixed axis, point *A* of connecting rod *2* of slider-crank linkage *1-2-3*, and lamp bank *4*, suspended from point *A*, with its lamps *B*, have translational motion, describing connecting-rod curves similar to curve *a*.

| 1676 | SPATIAL SLIDER-CRANK MECHANISM OF A SHEAR WITH VARIABLE ANGLE OF INCLINATION OF THE KNIFE | SC FD |
|---|---|---|



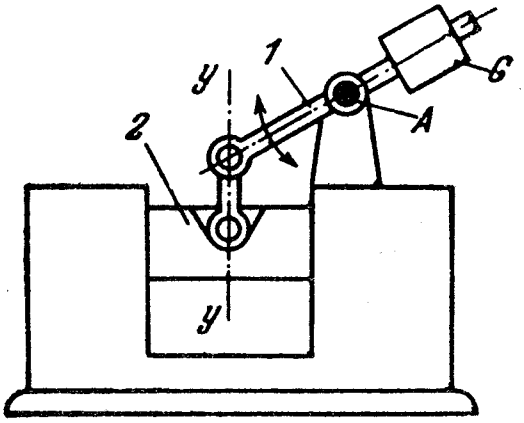

When disks *1* and *2* rotate at equal angular velocity, the edge of movable knife *3* moves up and down along fixed guides *4*, occupying positions $B_1$-$C_1$, $B_2$-$C_2$, . . . Thus the angle between the edge of the knife and the stock varies periodically. Spherical pairs are provided at points *A*, *B*, *C* and *D*. At points *C* and *D* on disks *2* and *1* the pairs are displaced by 90° from each other.

| 1677 | SLIDER-CRANK MECHANISM OF A DOUGH-KNEADER WITH A CIRCULAR GUIDE | SC FD |
|---|---|---|



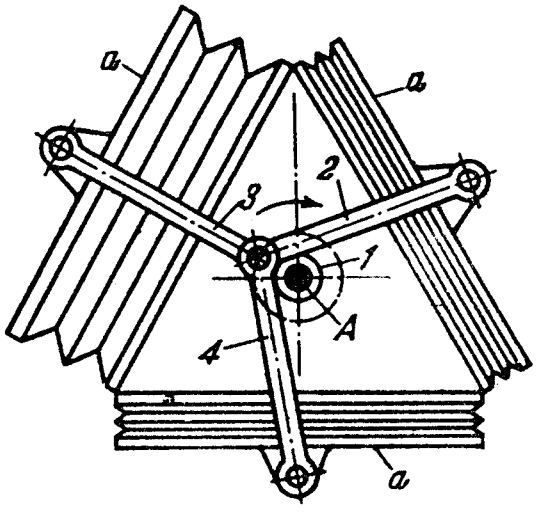

When crank *1* rotates about fixed axis *A*, point *E* of connecting rod *2* describes path α-α. Connecting rod *2* is a prong which kneads the dough in vessel 3. Slider *4* moves along a circular guide of radius $\overline{DC}$ and with its centre at point *D*. The mechanism is equivalent to four-bar slider-rocker arm linkage *ABCD* in which *AB* is the crank and *CD* is the rocker arm.

| 1678 | SLIDER-ROCKER ARM SHUTTER MECHANISM | SC FD |
|---|---|---|



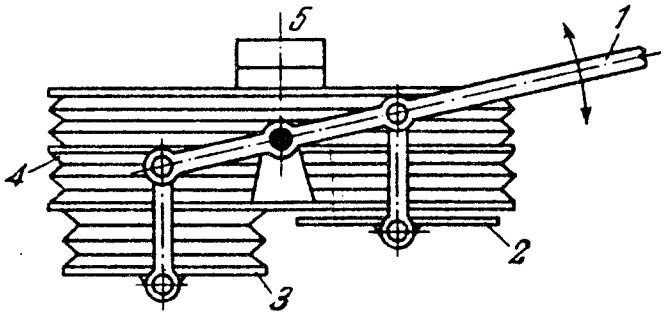

When link *1* oscillates about fixed axis *A*, link *2* (the shutter) reciprocates along axis *y-y*. Weight *G* counterbalances shutter *2*.

| 1679 | SLIDER-CRANK TRIPLE BELLOWS MECHANISM | SC FD |
|---|---|---|



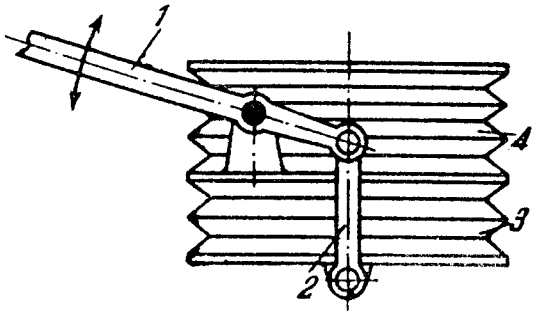

When crank *1* rotates about fixed axis *A*, three connecting rods, *2*, *3* and *4*, connected by turning pairs to crank *1*, spread and compress three bellows *a* so that they draw in air and discharge it, one after the other, in turn.

| 1680 | SLIDER-ROCKER ARM MECHANISM FOR A BLACKSMITH'S BELLOWS | SC FD |
|---|---|---|



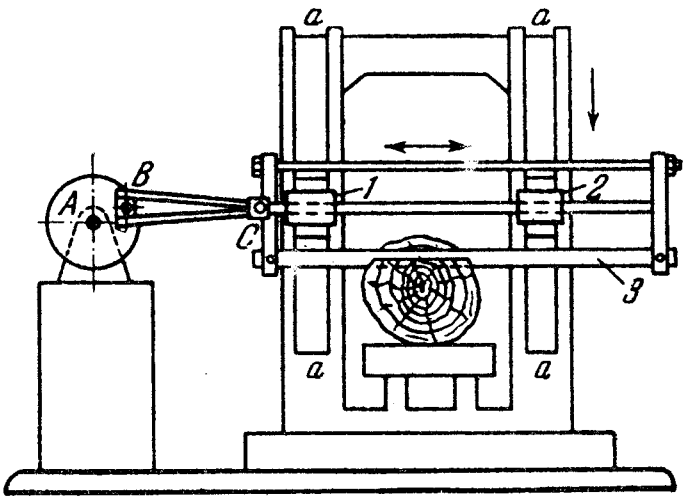

When lever *1* is oscillated, feeding bellows *2* and *3* alternately draw in and pump out air. Upper two-row bellows *4* serves for levelling off air discharge. The pressure of the blast can be regulated by varying the load applied to bellows *4* by weight *5*.

| 1681 | SLIDER-ROCKER ARM MECHANISM FOR A BLACKSMITH'S BELLOWS | SC FD |
|---|---|---|



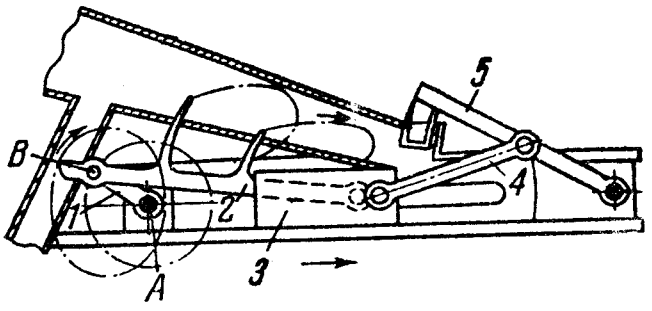

When lever *1* is oscillated, bellows *3* alternately draws in and pumps out air. Upper bellows *4* serves for levelling off air discharge.

| 1682 | SLIDER-CRANK MECHANISM OF A LOG CROSSCUT SAW | SC FD |
|---|---|---|




Sliders *1* and *2* move along guides *a-a*, as a result of which saw gate *3* has vertical downward feed. Saw gate *3* with the saw is reciprocated horizontally by slider-crank linkage *ABC*.

| 1683 | SLIDER-CRANK HAY BALER MECHANISM WITH ATTACHED CONNECTING ROD AND ROCKER ARM | SC FD |
|---|---|---|




When crank *1* rotates about fixed axis *A*, pressing piston *3* oscillates. Hay is advanced by tines on connecting rod *2*. Rocker arm *5*, oscillated by link *4*, packs hay into the pressing duct.

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